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ABSTRACT

This publication is a collection of energy education articles for the classroom teacher. Most of these articles suggest energy education activities and projects that may be used as is or modified to fit classroom conditions. Two energy mini-units are included as well as a collection of energy lesson plans. Contents include: (1) Teaching About the Nuclear Power Controversy by Simulation; (2) Our School-Made Solar Project; (3) Six Ways to Reduce Energy Consumption; (4) Leisure and the Energy Crisis; (5) Some Guidelines for Energy Programs; (6) Energy Teaching Centers; (7) Which Source of Energy is Best for Heating My Community?; (8) Energy and Its Natural Sources; and (9) Energy Resource List. Many of the articles also include student or teacher resource lists as well as activity suggestions and informative texts. A rationale for energy education is presented in the first article. Brief descriptions of each article are also included. (CS)

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Energy and Education: Teaching Alternatives

U.S. DEPARTMENT OF HEALTH,
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Contents

FOREWORD	7
Energy	
by Ernest L. Boyer	9
Teaching About the Nuclear Power Controversy by Simulation	
by Thomas Tanner	15
Our School-Made Solar Project	
by Jerry Silver and Kurt Johnson	17
Investigating the Aerosol Issue	
by William C. Ritz	21
Six Ways to Reduce Energy Consumption	
Office of Consumer Affairs and U.S. Department of Commerce, National Bureau of Standards	28
Solid Waste—Individual Citizen Action Check List for the Home and Community	
Citizens Advisory Council on Environmental Quality	36
Leisure and the Energy Crisis	
by Max Kaplan	39
Net Energy: Figuring the True Yield	
by John W. Moore and Elizabeth A. Moore	45
Some Guidelines for Energy Programs	
by King C. Kryger	49
Energy Teaching Centers	
by Lois E. Kenick	54
Where Does America Get Its Energy?—Energy Conservation	
Activities for Young Learners	
Office of Conservation Education, Federal Energy Administration	59
Mini-Unit 3: Which Source of Energy Is Best for Heating My Community?	
Energy-Environment Mini-Unit Guide	68
Mini-Unit 4: Energy and Its Natural Sources	
Energy-Environment Mini-Unit Guide	83
Energy Curriculum Lesson Plans	
by Fredrick E. Posthuma	125
Energy Resource List	
by Fredrick E. Posthuma	137

The Editor

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Foreword

"Energy Education? Can't say I've heard too much about it," or, "I'd like to teach it, but I'm not prepared," or, "I'm satisfied with what I'm teaching now." These and numerous other answers are often given by educators when asked why they do not include energy as an integral part of the curriculum. It is time to teach a new and extremely relevant subject in our classrooms. It is time to bring about attitudinal changes and conceptual development in relation to the energy and power field. First, let's briefly review the short-lived history of energy education. Then let's look at the state of the art in terms of energy education today.

In late 1973 and early 1974 the energy crisis became full blown. Until that time energy education was relatively unknown in the school systems of the United States. Granted, several future-focused programs used a few energy-related materials in the classroom, but energy was not really considered an integral part of the curriculum. It played a remote secondary role instead of a primary role in the classroom. Very little attention was given to the energy issue at the primary, secondary, or post-secondary level.

Suddenly a few people began to realize the severity and long-range effects of the problem. Education, government, industry, and the general public expressed some concern. Because of the lack of information and general public apathy, however, the energy issue was for the most part ignored. Eventually some educators began to incorporate energy materials into the curriculum. Instead of playing the remote secondary role as before, energy began to play a more primary and important role in our schools. The number of courses is growing rapidly as educators realize the importance of energy instruction in terms of their own and future generations' human survival and industrial advancement. At this moment, however, there are comparatively few schools in the United States that include energy as an integral part of their curriculum.

Where does that leave us? What can you as a teacher do *now* to implement energy education in your instructional programs? Some brief suggestions follow.

1. Teachers at all levels, in all subject areas, should become involved. Even now, we may be ten years too late. More time cannot and should not be wasted.

2. Locate curriculum materials already developed for your particular discipline. There is a multitude of materials available—some of it mentioned in this publication. Try these materials and modify them to fit your program.

3. Develop your own curriculum materials to fit your program. Be sure to share them with friends, because it is important to circulate materials so that other instructors may use them. You need not develop an entire course, but do include as much as your discipline requires. If a new course called "Energy" could be established, so much the better.

4. Join professional organizations such as NECEP (National Educational Council on Energy and Power) on the local, state, and national levels. Attend energy conventions and displays. Take students along.

5. Most of all, believe in what you are teaching. Know your subject matter well. It is difficult to pretend that you are sincerely convinced of the energy problem if you are not. Students will notice your attitude and will not approach the problem seriously. Also, be familiar with the material. Research it and provide your students with the most relevant information possible. Keep up-to-date.

At this moment the future of energy education K-12 appears promising. New and better materials are being developed. Skeptics have finally realized that the problem is real and will deepen in the future. We have an urgent job to do. It is extremely important that today's young people understand energy and all its implications. One might say their lives depend on it.

This book is a beginning. It contains many informative articles on all aspects of the energy question. It also suggests resource materials which should be helpful for those who are just starting out as well as for those who are energy veterans. It is designed to help you present an interesting and effective program in energy education.

Fredrick E. Posthuma

The energy crisis facing the nation requires not only new technologies, but new values and attitudes as well. This article describes the importance of educational responsibility and suggests how the Office of Education can be of help to the schools.

Energy

ERNEST L. BOYER

U.S. Commissioner of Education

A decade ago Arnold Toynbee observed that we have conquered nature and that now our great unfinished task is to conquer self. He said that humanity is our most formidable enemy today.

The time has come, Toynbee said, for humanity to unite against the common enemy in itself. The great irony of our time is that humanity may be destroyed, not by its madness, but by its carelessness—by its wanton disregard for its special relationship to the planet Earth.

Catastrophes, of course, are not uncommon. Since humanity first stirred itself, we have faced wars, disease, hurricanes, and floods. These calamities have struck, they have taken their toll, and they have departed, leaving us to rebuild ourselves.

I'd like to suggest that the crisis of which Toynbee spoke—our use and misuse of nature's resources—is a disaster of a different kind. Unlike flood or hurricane, it is a dilemma we have made ourselves. Unlike disease, there is no miracle drug which can provide an easy cure. And unlike war, there is no armistice in sight. The energy crisis we confront today will be with us for as far ahead as we can see.

But whether this crisis becomes a catastrophe is largely up to us. In explaining to the nation the urgency of his national energy plan, President Carter noted that "with the exception of preventing war, this is the greatest challenge that our country will face during our lifetime." And he told Congress, "It will be a test of our basic political strength and ability. But we have met challenges before and our nation has been the stronger for it. . . . I am confident that . . . we will succeed."

Today our planet has begun to show signs of the strain of sopping up the wastes of our constantly accelerating energy use. In addition, we are running out of known resources of gas and oil—the fuels that represent almost three-quarters of the energy upon which the U.S. economy depends. This is a physical fact, a physical problem.

Suddenly, we are beginning to discover that exponential growth is not forever possible in a finite world. This is undeniable, no matter how badly we may want it to be otherwise.

Like all systems that have been jolted out of their inertial pathways by some massive interruption, the total human system is calling on all its parts to find new energy sources that will enable us to continue solving all our societal problems by more growth. But to seek new sources of energy in order to build even more sprawling and random additions to our urban jungles, to fuel our luxuries, seems sadly unrelated to the true nature of our problem.

It is true that alternative forms of energy may help us cope as our oil and gas gauges plummet toward zero, but to think that the chief task of a world with dwindling resources is to hunt for new resources to exploit is myopic vision at its worst. It makes a false assumption. It presumes that our present style of life can continue. It leaves unchallenged the idea that our centuries-old energy binge must roll ahead.

Here's my point. The energy crisis we now face will require not only new technology, but new values and new attitudes as well. We must change our habits of consumption. We must approach self-indulgence with a new perspective—an understanding that we are members of a human community with a common plight and a common fate. And all of this is closely tied to our nation's schools and colleges.

Specifically, I believe energy, environment, and education are linked together in three fundamental ways:

- First, the nation's schools and colleges are major consumers of energy. They, like the rest of society, must learn to cut back on consumption.
- Second, education must train individuals with the technical know-how to lead us toward a conserving society. New careers require new educational preparation.
- Third—and perhaps most important—our schools and colleges must confront today the realities of the 21st century and begin to focus on the perspectives and attitudes that will be critical in ensuring our global survival in that era.

Each of these tasks—conservation, training, and curricular change—represents a major challenge to our educational system. With the right leadership and vision, I believe the system can succeed.

Our nation's schools consume 11 percent of the heating and cooling fuel in this country; yet it has been estimated that almost half the energy they consume is wasted because school buildings were constructed without regard to energy conservation. There are 79,000 elementary schools in the

United States. The most conservative estimate available indicates that at least 50 percent of them need major retrofitting.

The Federal Energy Administration has estimated that if only 30 percent of the nation's elementary and secondary schools were to become energy efficient through renovation and winterization, 25 million barrels of oil could be saved each year.

The Department of Commerce has indicated that with no capital modifications at all—simply by changing operating methods—schools can reduce their energy consumption by 5 to 25 percent. With minor capital modifications, involving very small expenditures, another 25 to 35 percent could be saved.

In 1972-73, the schools spent \$1 billion on energy. In 1976-77, the bill was over \$2 billion. This amounted to \$19.81 per student in 1972 and \$41.60 last year.

Late 1976 projections indicated that the cost of gas, coal, and electricity would increase 20 percent annually through 1980. Thus, in a little over three years, most fuels and electricity will cost double what they do today.

School districts will have no choice but to find more and more ways to conserve energy. Some will establish full- or part-time "energy coordinators" and energy conservation teams. They will develop energy management plans and conduct a school energy audit. They will adopt good plant maintenance practices, including preventive maintenance. And they will ensure that new construction is designed and built to save energy.

But schools and colleges, of course, are more than physical plants. They also provide the knowledge and skills necessary to embark on careers.

What new professionals do we need today and will we need even more by the end of the century? If coal is to be a short-term solution in our transition to a conserving society, then we will need to train professionals in new mining technology. We will need environmental experts capable of monitoring the public interest in that industry. Solar and wind energy generators remain a dream and a promise; we need the personnel who have the skills to translate that promise into reality.

Universities, it seems to me, must focus their great research capacity on the problems of pollution and find effective ways to clean our air and clear our waters. Is it too much to expect that, in time, we might have nonpolluting cars, nonpolluting energy, and nonpolluting detergents? To be sure, we are already making some progress in this direction, but we still have a long distance to go.

We must search for ways to use our science and technology, not to promote endless growth and unproductive opulence, but to enable us to breathe clean air, to drink pure water, to conserve our natural resources. In other words, we must learn to live like civilized beings within the restraints of nature—restraints which can no longer be ignored with impunity.

Schools must conserve. They must contribute to the training of workers in the new energy and environment fields. And they must do more: They must teach our children and ourselves about the wider nature

of our energy dilemma and must equip our society with the understandings necessary to remake our society in the light of that dilemma.

I realize full well that what I am advocating is that wrenching occurrence known as "changing human values," a psychic event that is often as cataclysmic as the earthquakes and volcanoes that change the real territory.

We must start at the simplest level: awareness. A recent Gallup poll suggests that if Americans were taking an examination on the energy problem, many of them would flunk. Only half the public—52 percent—know that America must import oil to satisfy its current energy demands. And of those, only 17 percent—or 9 percent of all adults—have an accurate idea of how much petroleum the United States imports. Today nearly 3 out of 10 college-educated citizens think that the United States produces enough oil for its present needs. Most Americans just don't know or don't realize how big those "needs" actually are. While we make up a mere 6 percent of the world's population, we consume a third of its energy.

But awareness alone is not enough. I submit that all of us in education must constantly stress the need to understand and to respect the unity of life—a unity within which the energy problem can be seen as one part.

In the late 1960's, we began to notice that something disastrous was happening to our natural world—the world of physical/biological systems like air and water and wildlife—and we called it "the environmental crisis." We responded to it in the educational community by developing a fragment we called "environmental education," and we tacked it onto our institutional machine like a bumper strip and congratulated ourselves on a good job.

Just the other day we began to notice that our human world—the world of societal systems like the economy, government, industry, and even education—was in trouble. It was running out of the energy fix it requires to keep it developing along traditional growth lines. The immediate reaction was to run out and invent yet another fragment and call it "energy education."

This time I have high hopes that we can resist the fragmented approach. Our many problems are one problem; they are of a piece, and they cannot ever be "solved" in the sense of arriving at some Utopian conclusion. They are the problems of complex systems in constant motion, and approaches to solutions must take the same dynamic path, must be able to shift to new modes as the problems shift.

For the first time in the conscious history of humankind, we are becoming aware of the many pieces of our puzzle, and they add up to one interrelated system—the complex web of human culture and society with all its interrelated parts, and the physical/biological world within which the human-built world is embedded.

One of the tragic by-products of our age has been the inevitable "breaking up" of knowledge—and for this we have paid an awesome price. In our drive for progress, we have become specialists and have fragmented our efforts. In doing so, we have collided disastrously with nature and,

indeed, with truth itself. In spite of its diversity, nature, like truth, spins a unified web.

If this is so, how can unity be preserved? How can balance be restored? The answer seems to be, at least in part, in the way we educate ourselves and in the way we think about ourselves. We must see more clearly and understand more completely the unity of our world, not just in a physical sense but in a social sense as well. We must constantly remind ourselves that nothing is ever wholly destroyed and that all of our moves on this planet—whether physical or social—are intimately interlocked.

And in this effort, the schools and colleges will be crucial. They will have to abandon the fragmented approach to knowledge and the shattered perspectives from which we examine our globe. They will begin to address themselves to the part of us that lives in a community and relates to other human beings. The schools will begin to ask what we have and hope in common and from this common human agenda will derive a curriculum to highlight and strengthen the linkages among ourselves and with our common future.

On other occasions I have suggested that reading and writing and arithmetic should be part of a common core curriculum. But the three R's are not enough. Perhaps our schools and colleges need to realize that the energy challenge will confront us all for the rest of our lives, that our environment is shaped by our patterns of energy consumption and is passed on as a legacy to all of our children, and that our plight in this nation is determined also by our active, interdependent engagement with all nations.

Perhaps these three themes—energy, environment, and engagement—could also be keywords in our nation's education system. Our common core might perhaps extend beyond the traditional three R's, and into these new three E's as well.

In all this, how can the Office of Education be of help to schools?

I propose that the Office establish an Energy/Education Action Center which will have as its mission the coordinating of federal agencies' educational responses to the President's energy plan.

The three educational goals of the Center will be—

1. Providing information and technical assistance to schools and colleges as they move toward effective energy conservation.
2. Giving support in the training of new energy and environment professionals.
3. Providing leadership and support in the development of new curricular materials focused on the three E's.

The Center will work closely with all units and interagency committees of government which are concerned with education's response to the new energy realities. It will draw on the staff, resources, information, and goodwill of those units. Through the use of interbureau teams, the Center will also bring together OE program personnel responsible for the scores

of existing energy- and environment-related programs in the Office of Education in order to focus their work more effectively on the goals of conservation, training, and curriculum. We will direct available discretionary funds on these goals and will develop plans to target new discretionary monies toward those ends.

Projects undertaken by the Center might include the following:

- Serving as an information and technical support clearinghouse for all federal departments, agencies, and committees with education programs in the energy conservation and transition areas
- Developing a media approach, including the use of educational television programming, to spread public awareness and disseminate technical know-how
- Encouraging the development of new curriculums addressed to our fundamental global interrelatedness
- Sponsoring curricular innovations and demonstrating programs at all levels of education
- Developing curriculum guides in fields like insulation and solar energy and resource conservation
- Preparing a technical assistance plan to help schools conserve
- Installing a toll-free telephone line to provide immediate technical assistance and curricular guidance
- Building effective links between the government and the private and nonprofit sectors.

We hope to be a magnet for all federal efforts in educating our nation toward responsible membership in a conserving, interdependent world. We hope to aid the major national educational associations as they confront the new energy realities. And we hope to be of service to the state departments of education as they formulate their own plans of action.

In the few months that I've been in Washington, I've been struck by the frequency with which people refer ominously to "next winter" whenever they speak of energy. I think we must break free from the mentality that equates our energy crisis with last winter or next winter or any winter. *Crisis*—to return to its Greek root—means "decision." Let us decide today to abandon our panic and siege mentality. Let us decide to see today's worries about gas and oil as the signal of a much more profound, much more transcendent problem in our relations with our globe and with one another. Only in that broader context of who we are as a society and what world we want our children to inherit can anyone's energy agenda make sense.

This short article presents a simple simulation that can be used to teach secondary students about the nuclear power controversy. It also includes a bibliography for student reference.

Teaching About the Nuclear Power Controversy by Simulation

THOMAS TANNER
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Discussion of the nuclear power controversy must inevitably turn to the place of nuclear power in a mix of energy alternatives, including solar, wind, geothermal (using the earth's subsurface heat), coal, atomic fusion, and others. (Atomic fusion is still in the experimental stage and is not highly controversial. Atomic fission is the current—and controversial—nuclear power process.)

A simple simulation can be used to teach about this controversy. Divide the class into several groups: a Congressional committee, a pro-fission group, an anti-fission group, and several groups advocating various alternatives as represented in the bibliography below.

Now set the scene. The committee is considering two different allocations for the budget of ERDA, the federal Energy Research and Development Administration. The first is from the President's recommendations, and calls for the budget to be 90% for atomic fission projects and 10% for other projects, with the assumption that this type of allocation will continue for several years. The other recommendation is from an opposition bill arising in the House of Representatives; it proposes a five-year phase-down of fission expenditures, resulting in a final allocation of 30% for atomic fission projects and 70% for other energy sources. The committee is to hear testimony from the groups before choosing one of these allocations, or arriving at one of its own.

Groups may use such information sources as those listed in the bibliography. Decide upon a time limit for the presentation of each group, such as thirty minutes. Perhaps allow a briefer time for formal rebuttal. The class might participate in rule-making. Keep the rules simple and few. While the committee is making its final decision, have the other students

come up with their own allocations in two forms: (1) "My allocations as a member of my group," and (2) "My allocations as I think they really should be."

Also, the committee could be asked to consider the following. Each of the two proposals calls for the *fission* portion of the budget to be subdivided thusly—95% energy production, 5% reactor safety, waste management, and transport safety. Does the committee wish to modify these sub-allocations?

What do the following references reveal about the *actual* allocations and sub-allocations? Have these shifted in recent years? A student volunteer could request more information on the history of these allocations by writing ERDA at Oak Ridge, Tennessee 37830.

References That Are Useful for the Simulation

"In Support of Fission." *Saturday Evening Post*, December 1975; *Scientific American*, January 1976. Additional free and inexpensive materials can be obtained from: your local utility; ERDA; Atomic Industrial Forum, 475 Park Avenue South, New York, New York 10016; American Nuclear Society, 244 Ogden Avenue, Hinsdale, Illinois 60521; Reddy Kilowatt, 537 Steamboat Road, Greenwich, Connecticut 06830.

"Critical of Fission." *Smithsonian*, April 1974; *Ladies' Home Journal*, October 1974; *Social Education*, February 1976; *Living Wilderness*, Spring 1974. Also check the "Nuclear Blowdown" section in each issue of *Not Man Apart*, published by Friends of the Earth, 529 Commercial, San Francisco, California 94111.

"General Articles Describing Various Alternatives." *National Geographic*, November 1972; *Environmental Action*, February 2, 1974; *Saturday Review*, February 16 and 23, 1974; *Science*, April 19, 1974; *New York Times Magazine*, March 16, 1975; *Audubon*, September 1975. (For intermediate to junior high reading levels: *The Curious Naturalist*, December 1974, fossil fuels; January 1975, solar; February 1975, geothermal, fission, fusion; March 1975, energy from waste; April 1975, summary of pros and cons on all sources of power; May 1975, energy in nature. Also, see *Ranger Rick* for March-April and May-June 1974).

"Solar Power." *Science News*, January 27, 1973; *National Wildlife*, August-September 1974; *National Parks & Conservation*, October 1974; *Sierra Club Bulletin*, May 1974; *Environment*, June 1973 (somewhat technical); *National Geographic*, March 1976.

"Fusion." *Scientific American*, February 1971 (somewhat technical); *Smithsonian*, December 1972; *National Wildlife*, October-November 1973; *National Parks & Conservation*, January 1975; *Environment*, May 1972 (technical).

"Geothermal." *Science Digest*, July 1974; *Time*, March 4, 1974 (very brief); *Smithsonian*, November 1974; *Business Week*, March 17, 1973; *Saturday Review*, March 23, 1974; *Newsweek*, February 1973; *Science News*, July 13, 1974; *Environment*, December 1971.

"Wind." *Audubon*, May 1974; *Popular Mechanics*, November 1974; *Smithsonian*, November 1973; *Aviation Week*, April 1, 1974; *Environment*, January-February 1973; *Organic Gardening & Farming*, January 1974; *Rodale's Environment Action Bulletin*, June 14, 1975; *National Geographic*, December 1975.

"Conservation and Other Alternatives." *Conservation: Smithsonian*, October 1973 and March 1974; *Sierra Club Bulletin*, December 1972. Conservation of "wastes" into methane gas; *Environment*, December 1971, September 1973, March 1974.

A need—a challenge. That's what students at Central Senior High School in Prince George's County, Maryland, were faced with when threatened with the closing down of several temporary school buildings to conserve propane. The answer—solar energy! The design and construction of a solar panel!

Our School-Made Solar Project

JERRY SILVER

Science Teacher,

and KURT JOHNSON

Science and Mathematics Teacher,

Central Senior High School,

Seat Pleasant, Maryland

The fuel shortage last winter affected us directly at Central Senior High School in Prince George's County, Maryland. Many of us were holding classes in temporaries, freestanding, prefabricated structures that were heated by propane. The Board of Education closed several temporaries to conserve propane.

At that time, our desire to do something about the situation led us to consider the possibility of making a simple solar collector with our math and science students. We had seen a newspaper article about a type of solar collector made with beer and soda cans that were painted black to absorb the sun's energy. Placed in a glass-covered box, the cans heated the air in the box. A fan could then blow the heated air from the box into a building.

We also knew that a Central High School student had built a small model of this type of solar collector and had won first place at the 1976 Prince George's County science fair with her project.

We wanted our students to build an expanded version of this type of collector, which would sit on the roof of a temporary and reduce the amount of fuel needed to heat it. When a neighbor decided to throw out a set of old storm windows, we had a solar collector cover, and we began to make plans for our project.

We included students in the design process by having them draw up their conceptions of how solar energy could help to heat the classroom. One student who had been studying about solar energy in an environmental science class suggested making the collector movable so that it could always be perpendicular to the sun's rays and achieve a maximum heating effect.

Another wanted it to be curved so that a part of it would constantly be facing the incoming rays of the sun.

After several discussions about various alternatives, we agreed on an initial design. Two students who were enrolled in drafting classes at Central made detailed drawings of these original plans for students to use. Others arranged the storm windows on the ground and figured out the surface area of the windows, which gave them an idea of how much energy a collector that size would provide.

Then we asked how much energy would be needed to heat the classroom. To get a handle on this, we needed to know the volume of the classroom. Given this problem, the students began figuring the dimensions of the classroom. Part of the classroom was a rectangular solid, and they recalled enough geometry to calculate that volume. But what about the volume of the triangular solid under the sloping roof? They already had all the measurements they needed except one—the distance down the slant of the roof from the ridgepole to the top of the wall. But that distance is the hypotenuse of a right triangle whose base and height they knew. So they could use the Pythagorean theorem.

It was one of those rare moments in teaching when the teacher can calmly sit and say "glad you asked" in response to the students' question. The practical application of the theory was directly apparent.

After consulting books such as the *Energy Primer* (Portola Institute, 1975) and the *Solar Home Book* (Cheshire Books, 1976), we realized that the approximately 5.5-square-meter (60-square-foot) collector we wanted to build would contribute only a small percentage of the temporary's heating needs.

Meanwhile, Larry Hervey, a Prince George's County instructional supervisor, became interested in what we were doing and was able to obtain around \$850 from the Board of Education to fund the project. This enabled us to expand our goals and build a somewhat more ambitious collector than the one we had previously planned.

We shifted from trying to build a demonstration model that would in effect be an educational toy to building something that would significantly contribute to the heating needs of the classroom. We wanted to reduce the county's heating bills enough to have the project pay for itself within a few years—which at the current price of propane seems like a reasonable goal.

With the help of our students, we redesigned the system so that it would make a larger contribution toward heating the classroom. Since we needed additional glazing material, we chose a shatterproof plastic material called Kalwall Sunlite that would be much easier to work with and would enable us to cover a larger area.

Soon our materials, which had been ordered from local suppliers, started coming in: plywood, nails, caulking compound, heat-resistant paint, aluminum flashing, fiberglass insulation, and a squirrel cage fan.

Students began collecting beer and soda cans to absorb and reradiate the solar energy we were trying to capture. We needed roughly a thousand

cans. Collecting them added several side benefits to the project: We recycled cans that otherwise would have wound up as landfill, and we made a small contribution toward reducing the school's litter problem.

As soon as we had our materials together, we began building on a weekend the six 2.5 m x 1.2 m (8' x 4') panels that were to make up the collector. About 20 students turned out to help. By the end of the day, we had three boxes pretty well assembled. (One student got an unplanned lesson in the potential power of reflective surfaces when he got a mild but unexpected sunburn after working in an aluminum-lined collector box for several hours.)

As the project progressed, we observed interesting social aspects of the students at work. From the first day, we had two self-appointed student "foremen" who outdid each other in giving orders. We tried to help them function cooperatively rather than competitively. Most of the girls tended to shy away from the physically demanding tasks and got stuck doing the "feminine" tasks, such as rinsing out the opened cans. Finally, we were able to persuade them to assume different roles, which most of them handled quite well.

In considering different ways of attaching what would be a 2.5 m x 7.3 m (8' x 24') collector panel at a 54° angle securely to the roof, which had a 15° slope, we wanted to make sure that the roof would be strong enough to support safely our collector (as well as several people working on it). After calling the county maintenance department, we got the word that we could not trust the thin roof of the building. So within a few days, Larry Hervey had arranged with the Potomac Electric Power Company to have six telephone poles donated to the school to support the collector.

The maintenance department drilled holes for us. Then, using Larry's dump truck and about a dozen students, we eased the poles into the holes. We had a little trouble with the third one, which almost crushed the roof of a nearby temporary as it swung too far while we were dropping it into its hole.

During the next couple of weeks, we completed the collector boxes and were ready to mount them on the telephone-pole frame. This was probably the most difficult part of the project and required the greatest amount of trust and cooperation among the people working on it as we lifted the massive boxes onto the poles.

We had to cover the boxes with Kalwall immediately because if it rained it would have been extremely difficult to empty out the water accumulated in a thousand opened cans.

From that point on, it was a matter of finishing up: a second layer of Kalwall, side insulation, thermometers to monitor input and output temperature, and a fan to make the heated air move. A local electrician donated a differential thermostat and installed it in compliance with building codes.

A sheet metal worker donated ductwork, and we installed a solar cell next to the collector in order to give an indication of hourly solar intensity and assist in setting up experiments to determine the collector's efficiency.

When we turned the fan on, we felt a continuous flow of warm air

coming in from the vent. Even though it was a warm day, we let it run until the temperature in the classroom was well above 32°C (90°F), because we were all so excited to see the collector working.

On one sunny day, the temperature of the air coming out of the vent into the classroom reached 116°C (240°F), which literally broke the thermometer we used to measure it. On an overcast day, it measured 52°C (125°F). Even on a rainy day, it was 4°C (8°F) higher than the temperature of the surrounding air. We were quite pleased to see the system work at all—but the real test will come this winter when we try to use it to heat the classroom.

This project gave us a chance to interact with students in a new context and provided a vehicle for students to tie in what they were doing in other classes. For example, students in woodworking classes used their skills in building the collector.

It also gave us many opportunities to present concepts that are part of our regular math and science curriculums. For instance, geometry was required in studying how to tilt the collector in relation to the sun.

This year we anticipate being able to use the classroom as a solar lab. We plan to monitor the amount of heat supplied by the sun and compare it to the amount of heat needed by the backup propane system. We can study how efficient the collectors are under different conditions—such as different outdoor temperatures, different amounts of available sunlight, different times of day, and different fan speeds.

We would like to come up with an estimate of the cost of operating the system by measuring the amount of electricity required by the fan on a month-to-month basis. This will enable us to determine to what extent we have contributed to reducing the classroom's heating bills. Some important questions to be considered are: Is the system practical compared with conventional heating methods? And is it an efficient use of solar energy compared with other forms of solar heating, such as circulating water or passive systems—for example, a window facing south.

Probably the strongest message that students receive from their school about energy is the example set by the school itself. The types of energy choices made by an educational institution influence students' perceptions of what is appropriate use of energy. We hope that our students at Central High School will have a greater sense of the possibility of using solar energy in the future.

A look into the possible adverse effects fluorocarbon aerosols may have upon our ozone layer with a sampling of student activities provided to challenge students and instructors in forming their own opinions on the aerosol issue.

Investigating the Aerosol Issue

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Imagine a day in the near future—perhaps even next year—when the President of the United States signs into law a bill limiting to three the number of aerosol products a family is permitted to have or use. Which of the following aerosols would you select as *your* family's set of three?

- deodorant
- spray paint
- furniture polish
- dessert topping
- no-stick pan coating
- household lubricant
- insect repellent
- hair spray
- cheddar cheese
- window cleaner
- cologne
- oven cleaner

An impossible scenario? Not entirely! The "aerosol explosion" of recent years is currently being called to serious question. Inextricably tied

to each and every one of us, the aerosol controversy is likely to be at hand for some time. And because of this, the matter provides a unique opportunity to involve students in investigating an as yet unresolved environmental issue.

Should further aerosol production and use be restricted or even prohibited? Or has the case against aerosols been overstated? Upon what evidence do the critics and defenders of aerosols base their contentions? What, if anything, should individual citizens be doing about aerosols? These are questions of great importance to each person, and now would seem to be the teachable moment—the time when serious investigation of the issue should have high priority. Let's start by reviewing what the controversy is about.

In the upper reaches of the earth's atmosphere, there exists a layer of ozone many kilometers thick which acts as a protective shield, screening out excessive ultraviolet radiation from the sun. Because high intensities of ultraviolet radiation are harmful to nearly all forms of life, the protection given by this layer is vital.

If the ozone shield were to become reduced, the amount of ultraviolet radiation reaching the earth's surface might increase, and the resulting effects could be very serious. For example, the National Academy of Sciences has suggested that a 5 percent ozone reduction might produce an additional 8,000 cases of skin cancer per year among the white population in the United States alone. Another estimate, reported in *Fluorocarbons and the Environment: Report of Federal Task Force on Inadvertent Modification of the Stratosphere (IMOS)*,* is that a 1 percent reduction might produce from 2,100 to 15,000 new cases annually among light-skinned Americans.

Other possible effects include weather/climate changes, increased mutation rates among plants and animals, and direct plant toxicity.

What does damage to the ozone shield have to do with aerosol products? First of all, half of the aerosol products sold are propelled by fluorocarbons—compounds of carbon, fluorine, and chlorine that may be better known by their trade names, such as Freon. (The other half are propelled by such substances as hydrocarbons, compressed air, and carbon dioxide. So far, none of these latter propellants is suspected of affecting the ozone layer, though some present other problems, e.g., the flammability characteristic of the hydrocarbons.) However, aerosols use only half of the fluorocarbons produced in the United States; more than a quarter goes into refrigerators and air conditioners. Leakage from these appliances over years of use and after disposal will also add fluorocarbons to the atmosphere.

Because fluorocarbon gases are highly volatile, nonflammable, and virtually inert to chemical reaction, they have been considered ideal propellants for aerosol cans. In the last few years, about 800 million pounds of fluorocarbons have been produced annually in the United States. However, recent research indicates that free chlorine, derived from these compounds, may bring about the destruction of large amounts of ozone in the stratosphere.

Apparently, the process works this way: Released into the lower atmosphere, the extremely stable fluorocarbon gases may be slowly circulated unchanged to the upper atmosphere—a process that could take years. Once in the upper atmosphere, however, the fluorocarbon gases may be broken down by ultraviolet radiation, thereby releasing atoms of free chlorine. It is the free chlorine atoms which in turn are suspected of being very effective at catalyzing the chemical breakdown of ozone into oxygen.

In June 1974, two University of California, Irvine, chemists, Mario J. Molina and F. S. Rowland, published a paper in *Nature* contending that fluorocarbon propellants may be depleting the ozone shield. Within months, scientists at Harvard, Michigan, and the National Center for Atmospheric Research researched similar theoretical conclusions. The Harvard study, for example, concluded that if fluorocarbon production and use continues at the present rate of increase (doubling every seven to eight years), the ozone layer will be reduced 10 percent by the year 1994 and 16 percent by the turn of the century.

In response to these predictions, environmentalists, led by the Natural Resources Defense Council (NRDC), are demanding that prompt action be taken to curb the use of fluorocarbon aerosol products.

Some scientists take an opposing position, however. They maintain that the ozone depletion theory is mostly speculation lacking in experimental verification. *Time* magazine recently quoted a leading British meteorologist, who said that the theory was "utter nonsense."

The aerosol industry has recently contracted with several university researchers to seek more definite experimental evidence. Unfortunately, these studies are estimated to require from two to three years, and environmentalists insist that we cannot afford to wait that long before taking action.

So far legislative and regulatory bodies have taken little action on fluorocarbons because they are waiting for the National Academy of Sciences to release a major report, due in April 1976, which will make recommendations for action. Given the potential political and economic ramifications of the issue, any proposed ban may be highly controversial. Remember that fluorocarbon aerosols are a \$2-billion-a-year industry.

In the meantime, the recent flurry of adverse publicity regarding aerosols is beginning to make its influence felt. One large manufacturer of household chemicals recently ran an almost full-page newspaper ad stating that "our company has removed all fluorocarbon propellants from our production lines in the U.S., and we are aggressively reformulating our product ingredients worldwide to achieve the same goal." The statement went on to promise that this company's future aerosol labels would clearly indicate the absence of fluorocarbon propellants.

Such product reformulations are these easier to achieve for some products than others. Whereas acceptable alternate propellants are already available for a good many household chemicals, other aerosols (such as personal products) which require a fine, well-controlled spray are more difficult to modify. In such cases, repackaging of the product might be

best. In fact, many nonaerosol deodorants and hair-care products are becoming increasingly popular, in part because of their lower cost.

Most challenging of all, however, may be that part of fluorocarbon production which ends up in air-conditioning and refrigeration equipment. Because most cooling equipment is designed and constructed to specific coolant specifications, it is usually not possible to simply substitute one refrigerant compound for another. Furthermore, most, if not all, of the currently available nonfluorocarbon refrigerants possess toxic or other hazardous properties.

For now, and until acceptable substitute coolants are identified, it might be best to focus attention upon reducing refrigerant leakage in existing equipment and recycling the fluorocarbons already in use in refrigeration equipment. Clearly, intensive study is required before these problems can successfully be resolved.

Aside from potential fluorocarbon-related damage to the ozone shield, there remain for consumers a number of other concerns regarding aerosol use. There is, for example, the matter of cost. Even the most superficial of price comparisons will reveal the high cost consumers pay for the convenience of products packaged in aerosol form.

Then, there is the matter of resource management: From an ecological standpoint, the empty aerosol container must be regarded as an enormous waste of this world's rapidly dwindling resources. The solid-waste disposal problem which the ubiquitous aerosol container presents to communities is also of concern. How does one properly "dispose" of something which should not be punctured or incinerated?

Perhaps of even more direct significance to consumers are the personal health and safety hazards which use of some aerosols appears to involve. The aerosol deodorant you may have used this morning bears a label warning which reads something like this:

CAUTION: Never spray toward face or flame. Do not apply to broken skin, and discontinue use if rash develops. Avoid heat or cold. Do not puncture or incinerate can. Keep out of reach of children. Avoid inhaling.

Upon thoughtful reflection, what do these words communicate to you?

The aerosol issues are obviously far from being resolved. Many questions remain to be answered before anyone can be certain about possible fluorocarbon-related damage to the ozone shield and its potential damage to life on earth. Should people voluntarily abstain from using fluorocarbon aerosols? Or would it be best to wait for more substantive data to become available? In view of the possible consequences, these and other questions about aerosols demand thoughtful consideration both at home and in the schools, and each person needs to decide what, if any, action to take.

Now for consideration of how to get students into the aerosol issue. Regardless of its ultimate resolution, the issue is one about which each person should become as informed as possible. With this in mind, here is a selection of activities designed to get students (and teachers) involved in serious investigation of aerosols and their use. A word of caution, however:

At present, capable, responsible, and honest experts really do not know for sure what the long-range global effects of fluorocarbon aerosols may be. Because of this, the central question on that issue is "Should we continue our present use of fluorocarbon aerosols during a time of great uncertainty?"

A Sampling of Student Activities

1. Ask students to list the aerosol products used in their own homes. Set up the survey so that the data each student brings in can be collated into an "all class" or "all school" report.

Classify the aerosol products according to criteria which are specified by the students themselves.

Find out which aerosols are fluorocarbon-propelled and which ones are propelled by other substances. (Students will probably learn that it is not currently possible to get this information from most aerosol labels.)

Survey other families in the community (or nearby areas) to find out if their patterns of use are similar or different.

Find out what the average family's total dollar investment in aerosols is.

2. Check the quantities of active ingredients on aerosol cans, and determine the cost per active ounce of one or more products. (Here again students are likely to discover that labels are a poor information source. Letters to manufacturers might be the best method for gathering this information.) Find the same product in nonaerosol form and repeat the process. Compare costs and determine each product's cost effectiveness.

Write a letter to a company which does not make an aerosol product available in nonaerosol form, inquiring why it does not do so.

Find out what it costs to produce an unfilled aerosol can.

Find out, for several types of products, what proportion of the aerosol can's volume contains nonactive ingredients. How much of this is due to packaging the product as an aerosol? How does this compare with the same product, packaged as a nonaerosol?

3. Keep track of your personal use of aerosols for a full day or week. How many of each type do you personally use? Examine the record sheet afterward, and ask yourself, "Could (should) an alternate have been used?"

Design a questionnaire or other survey technique which enables you to find out about the use other people make of aerosol products.

Conduct a survey to find out which aerosol products most people believe to be necessary.

Conduct a "silliest aerosol product" contest.

Conduct a "most beneficial aerosol product" contest.

4. Design some educational materials which can be used to inform someone else about the aerosol issue. Try out the materials and tell the class about your experiences, and your materials.

Design a poster that informs people about the aerosol issue. Get the poster displayed in a prominent place.

Design a radio/television "spot" which informs people about some aspect of the aerosol controversy. Try to have it aired on public radio or

television, or via cable television.

Compose a song or poem designed to get across a message relating to the aerosol issue.

Design an "aerosol issue" bumper sticker or tee shirt.

5. Gather up a random sample of five or more aerosol containers. Carefully read the labels on each can—especially the warning signs. How feasible is it for people to explicitly follow these instructions?

Write a letter to one or more manufacturers in which you describe your reactions to trying to follow label instructions explicitly. Ask the manufacturer for specific instructions: for example, how to use a hair spray without getting the spray near your face or eyes.

Find out whether manufacturers place these warning labels on the cans voluntarily or because some government agency requires them to do so.

6. Find out all you can about how aerosol cans work. CAUTION! Do not attempt to disassemble any aerosol cans! This is strictly a reference assignment.

Find out all you can about Freons and related propellant gases.

Find out all you can about the different types of aerosol can valves in use today.

7. List the potential health/safety hazards of various aerosol products. For each one listed, give your best estimate of how significant you believe the hazard to be.

Conduct a survey to find out what, if any, health/safety problems people feel they have encountered in using aerosol products.

Check the labels on a wide variety of aerosol products, and list any toxic/hazardous ingredients noted. How do the manufacturers suggest that users contend with these substances?

Find out all you can about the governmental agencies and laws which regulate the production and sale of aerosol products. What, if any, guarantees of safety do these agencies/laws provide to potential consumers?

8. Start a reference file on aerosols, including in it copies of reports, pamphlets, newspaper clippings, advertising copy, and the like—in other words, anything and everything that pertains to aerosols and their use. Have everyone contribute to it, and maintain this dossier for at least a year's time. Periodically, review it for indications of trends and patterns. Use the dossier as a central data source for student and teacher reference work.

Classify the reference materials in the aerosol dossier into useful categories.

Start class publication of a monthly "aerosol report" which provides readers with useful information and suggestions regarding aerosol use.

Make the file and your report available to local community people who might find much information useful (i.e., local environmental organizations).

9. Find out all you can about aerosol disposal in your community. What special treatment, if any, do the local solid-waste people give to waste aerosols?

Interview people in the community who deal with the disposal of waste aerosol cans. What, if any, problems do these materials pose for the community?

Pull together as much information as you can regarding your community's total annual use of aerosol products. On the basis of this information, calculate a best estimate of the amount of resource material your community discards each year as a result of aerosol use.

Based on these estimates, calculate other ways these materials (now wasted) might have been used. For example, how many pounds of steel used to make aerosol cans might have become how many bicycles?

10. Design a questionnaire for administration to a sampling of people in the local community. Find out what people really know about aerosols, their risks and benefits, and the potential environmental hazards which these products may present.

Use the data of the survey to compile a community report which indicates what people know about aerosols. Share your findings with the news media and the general public.

Start an educational campaign in your community to inform the public with respect to the things that the survey indicates they do not know.

11. Find out all you can about the aerosol industry's impact on our nation's economy. Nationally, how many people depend upon the industry for their jobs? Determine as best you can what the effects would be of a national aerosol ban.

Read current and back issues of journals published for the aerosol industry, as well as various journals of the chemical industry. What do these sources have to say about the aerosol issue, and, particularly, the economics of the industry?

Contact industry and labor representatives to find out what they have to say about the controversy. What action(s) do they recommend be taken?

Some Do's and Don'ts for Teachers

Remember that most of the current aerosol issues are still questions. If you start treating preliminary findings and hypotheses as facts, you might end up with egg on your face.

Make sure that both pro and con information on the continuing use of aerosol products is available to students. Avoid being biased.

If students want your opinion, give it honestly and freely, but be sure that they understand that you are presenting personal opinions.

Remember that, at least for now, you and your students won't be able to find "the truth" about the fluorocarbon question—even the experts aren't sure at this point.

Remember, too, that deciding not to do anything (using aerosols at the same rate "as usual") actually means that you *have* decided to act. Electing to take this course of action should be considered OK, providing that it is a decision thoughtfully arrived at.

Join in the investigations with your students; this topic is an important one for *you*, too.

Conservation of energy in the home can be an energy saver as well as a monetary saver. Six methods of summertime home conservation are presented in this article. Most of these methods may also apply in wintertime.

Six Ways to Reduce Energy Consumption

OFFICE OF CONSUMER AFFAIRS AND
U.S. DEPARTMENT OF COMMERCE,
NATIONAL BUREAU OF STANDARDS

A WORD IN GENERAL . . .

Appreciate the Benefits of Energy Conservation

Whether or not your home is air-conditioned, there are methods of improving its summertime livability. These will help to reduce the cost of cooling and to conserve national fuel and power (and environmental) resources.

Several of the suggestions offered are more easily carried out in some dwellings than in others, but all lead to lower cost or greater comfort, or both. In any event, it is important to have a "feel" for the concepts involved, regardless of whether you live in a house or an apartment.

The overall cost of air-conditioning depends on a complex array of factors—climate, type of building, the degree to which your house is thermally insulated, length of cooling season, local prices of power or fuel, cost of air-conditioning equipment and labor, and method of operation. It is not necessary to have precise overall cost information to consider the adoption of the steps suggested herein. Since individual circumstances vary, estimates are given when possible of the time needed to pay back an investment for a suggested improvement (assuming reasonable costs for materials and installation and a 6% interest cost on the money invested) with the yearly savings realized in the average case. After the investment is repaid the householder will continue to profit by the annual cost savings.

A cooling effect of 1000 Btu per hour costs about $\frac{1}{4}$ cent per hour

if the price of electrical energy is 2¢ per kilowatt-hour and that of gas or oil is equivalent to \$1.30 per million Btu. (A Btu—or British thermal unit—is a unit of heat measurement; 1000 Btu are equivalent to approximately 0.3 kilowatt-hour.) For different local prices for energy, the cost of cooling varies with the ratio of the local price to that given above. In conservation terms, this cooling effect also requires the combustion—either at the electricity-generating plant or at your building—of 1700 to 2000 Btu of fuel per hour. So if you are using 40,000 Btu per hour to cool your home and you effect a 10% saving in your energy consumption you benefit by 1¢ per hour or 24 cents per day—or \$24 savings if you have 100 cooling days. And the nation saves through the conservation of fuel.

In houses which are already air-conditioned, our suggestions can lead to savings in operating costs and to improved comfort. But when air conditioning is to be installed—particularly in a house yet to be constructed—it is important to realize that better insulation and sun shading can reduce the size and thus the initial cost of the necessary cooling equipment, as well as reduce operating expenses over the years. The equipment savings may be enough to pay for or more than pay for, the thermal improvements at the outset; certainly the annual operating cost savings will pay back the investment within a reasonable number of years.

The thermal improvement of buildings, especially through the greater use of insulation, means savings, through energy conservation and greater comfort for you and your family in winter as well as in summer.

Moreover, since the consumption of energy results in some environmental pollution, pollution abatement is achieved through care in your use of energy.

AIR INFILTRATION AND LEAKAGE

Prevent Excessive Entry of Outdoor Air

In an air-conditioned house you need outdoor air for ventilation at the rate of about 5 cubic feet per minute (cfm) for each member of your family. Ordinarily, this is enough to maintain freshness and to provide the combustion air for a gas-burning range and hot water heater. When outdoor air enters your house at a rate greater than this, energy is wasted and your cooling costs are needlessly high.

Assuming four persons in a household, the cost of cooling 20 cfm of ventilating air would be about $\frac{1}{4}$ cent per hour with outdoor conditions of 90 degrees and 50% relative humidity (RH) and indoor conditions of 75 degrees and 50% RH. But even in a tightly-built house the infiltration rate of outdoor air probably would be on the order of 50 cfm, and in houses with poorly-sealed windows, doors and joints the rate could easily exceed 100 cfm. The latter rate would cost about 1.2 cents per hour for cooling, or

nearly 30¢ per day, and the increase in humidity such infiltration causes would tend to make your home less comfortable.

Several things can be done to reduce air infiltration:

- Weatherstrip windows and doors at movable joints, and caulk cracks and openings at their frames; seal all cracks and openings in exterior walls.
- Keep windows and doors shut, and keep storm windows and doors in place during the air-conditioning season.
- If there is a fireplace, tightly close its damper.
- Close and seal all passages or openings between the air-conditioned space and the attic, including cracks around attic doors.
- If there is a large generation of water vapor or heat due to cooking, bathing, or washing, operate kitchen or bathroom exhaust fans, but only for as long as needed. In cooking, use covered pots and low fires when possible, especially when boiling.

WINDOWS

Shade Windows, Especially from Direct Sun

The daytime heat gain through windows, which typically comprise 15 to 30% of the exterior wall area of a house, puts a heavy load on air-conditioning equipment. Windows having ordinary glass transmit most of the radiant solar energy to which they are subjected and much of the heat from warmer outdoor air.

All windows, especially those exposed to the sun, should be shaded by one or more of the following means (percentage reductions in heat gain are compared with untreated ordinary glass windows):

- Blinds, draperies, etc.—Such devices can reduce heat gain through windows by as much as 50%. Their effectiveness depends on how well they reflect solar radiation back through the window. They should be light in color and opaque. And they should be drawn when sunlight enters your rooms—particularly in rooms not being used for the moment.
- Special glasses—Heat-absorbing and reflecting glasses can reduce solar heat through windows by 40 to 70%. These glasses have the advantage of doing the job while not interfering appreciably with the view.
- Awnings, overhangs, etc.—By far the most effective way to reduce solar heat gain is through the use of external shading devices such as awnings, overhangs, side fins, louvered sun screens and—yes—trees. These can reduce solar heat gain by as much as 80% if properly designed. A word of

caution: awnings and overhangs should be designed so as not to trap hot air in the window area.

The costs of these means of coping with heat gain vary, and your decision to adopt certain improvements would probably depend on an array of factors going beyond considerations of thermal comfort alone. You might, for example, decide to plant a tree not only for increased thermal comfort but to attract songbirds and to view its spring blossoms, autumn foliage and winter tracery.

Keep storm windows in place during the air-conditioning season on all windows except those to be used for ventilating. Storm windows—and insulating glass windows as well—may not stop the penetration of solar radiation but they form significant barriers to the transfer of outdoor air heat to the indoors.

INSULATION

Insulate Ceilings, Walls and Ducts

- **Ceilings**—the top-floor ceiling requires ample insulation to reduce the heat flow downward from the sun-heated attic. This ceiling barrier improves your comfort, returns you substantial savings in air-conditioning costs and avoids needless consumption of energy resources.

An installation of 6 inches of ceiling insulation will be paid back by savings in cooling costs in several years, and from then on will return a substantial annual dividend. Since the same insulation will greatly reduce heat loss in winter, the combined savings for air conditioning and heating will make the investment even more valuable—so much so that it may be returned in a year or two.

If your ceiling now has 3 or 4 inches of insulation, it is to your advantages to increase the thickness to the equivalent of 6 inches of good thermal insulation, since the additional investment will be returned in 3 or 4 years by the combined summer-winter savings.

- **Walls**—The walls of your house should be insulated with the equivalent of 3 or 4 inches of good thermal insulation. This will pay for itself in a reasonable number of years on the basis of savings in air-conditioning costs alone, but again, when savings for cooling and heating are combined, repayment of the investment is quicker. Well-insulated exterior walls—besides saving you money—contribute much to your thermal comfort and make room space near exterior walls more habitable in both summer and winter.

It is easy to insulate walls properly when a house is under construction. While walls can be properly insulated at moderate cost in many existing houses, expert technical advice should be sought to avoid problems that might arise due to moisture condensation within the walls.

- **Ducts**—In many central air-conditioning systems the cooled air is circulated to rooms through ducts which pass through the attic or through other non-cooled spaces. These ducts, especially those in hot attic spaces, should be insulated with an installed thickness of at least 1½ inches of typical, good fibrous insulation or its thermal equivalent. This is essential to conserve the cooled air for delivery to the space where it is needed and to avoid excessive operating costs because of heat gain in the ducts.

Your investment for adequate duct insulation will be quickly repaid, and once again, especially so if the same ducts are used to circulate warmed air in winter.

COOLING UNITS

Select the Type and Size That Meets Your Needs

Home air-conditioning equipment ranges from manually-controlled window units to complex central systems designed to provide independent temperature and humidity control in each room of the house. The simpler units emphasize economy; the complex systems emphasize comfort.

- The cooling equipment you select should be sized to hold the inside temperature at 75 degrees during all but the very peaks of hot weather. Experienced air-conditioning people can tell you what size equipment you need. Calculation produces are available from responsible air-conditioning dealers, contractors and related industry associations and professions.

Do not buy oversized equipment. When seasonal peak temperatures are reached a properly sized unit will operate continuously and the interior temperature will "swing" up a few degrees above the normal thermostat setting. Proper sizing and continuous fan operation work to counter two adverse conditions:

- Humidity**—Most residential cooling systems produce a steady relative humidity (RH)—typically 50%—only when operation of the unit is nearly continuous. Oversized units operate with shorter "on" periods and may provide less uniform humidity conditions.

- Stratification**—Continuous fan operation along with proper design of the air distribution system, including proper placement of air supply devices avoids having layers or pockets of air that are either too warm or too cool.

Properly sized equipment and adequate distribution provides the best combination for economy and comfort. But what kind of equipment?

- **Central cooling systems** generally provide the most effective and economical means of total-house cooling, especially when the duct work of forced air heating systems can be used as the distribution system. In many cases, all you need to add is a cooling coil and condensing unit, and probably a combination heating-cooling thermostat. If your heating system is other

than forced air you have to install a duct system for central cooling—or consider the use of window or through-the-wall units.

In fact, if your home has a number of rooms which are used infrequently and therefore do not require continual cooling, individual units for these rooms may be the most economical from the standpoint of both investment and operating cost. In other words, you need buy only as many units as you definitely need, and you need run those units only when the seldom-used rooms require their operation.

Window units are frequently undersized when used to cool large living rooms; in bedroom installations they are frequently oversized. All individual units which are left unattended should have thermostats to avoid excessive cooling; this is especially true of units used in bedrooms.

OPERATING PRACTICES

Operate Your System or Unit to Increase Comfort and Economy

How you operate the temperature, humidity and fan controls of air-conditioning equipment will have a significant effect on the comfort you attain and your cost of operation, whether you use individual units or a central system.

- Individual, or window units—These units provide cooling and indirect control of humidity; when properly sized and operated continuously they can keep down mugginess.

With any window unit the position of the adjustable louvers in the discharge air stream and the location of the unit itself should be chosen to mix the chilled air and the room air in a way that will not cause drafts on members of your family. If the circulating fan has more than one speed you can, in mild weather, lower the cooling effect, obtain more continuous operation and reduce noise by running the fan at lower speeds. Because most houses have enough natural air leakage for ventilation purposes the outdoor air damper should be closed to obtain greater economy and effectiveness. It can be operated to speed up the removal of cooking or tobacco odors. The greatest economy of window unit operation is realized when it is turned on only when needed and turned off when the space it cools is to be unoccupied for several hours.

- Central air-conditioning systems—Central systems employ a thermostat to start and stop the compressor, and sometimes the circulating fan as well, although greater comfort and uniformity of temperature within each room can usually be had by running the fan continuously (which for the cooling season might mean an addition \$5 in electric energy cost over cyclic operation). In more sophisticated systems, a humidistat may be used to control the house humidity and would require some type of reheat system to

simultaneously control room air temperature and humidity. Simultaneous control of temperature and humidity entails a greater outlay for equipment and usually greater operating costs, but does provide improved comfort in high humidity climates.

The thermostat should be located on an inside wall of the room where comfort is of greatest significance or in a hallway where it will sense the return air temperature from all rooms. It should not be located near electrical appliances or warm pipes, in direct sunshine or behind draperies or in any location where it is appreciably shielded from air circulation in your house.

Your house will be most effectively cooled if the distribution system is balanced so as to deliver exactly the right amount of chilled air to each room, and if the total air circulation is kept at the maximum. If your distribution system gets out of balance it can easily be corrected by the following procedure:

After the system has been operating for an hour or two on a hot day fully open all outlet grilles, or registers. If certain rooms get too cool, gradually close their registers until all rooms are at about the same temperature. This approach will produce balanced distribution with maximum air circulation. Under no circumstances should you close any register more than necessary.

In houses with central air conditioning you can save some electric energy by closing the door to an unused room. Unless the room is to be unused for an extended period of time, do not close the register in the room since the entire system would have to be rebalanced when use of the room is resumed. You may want to close kitchen and laundry-room doors during times of heat-generating activities in these rooms and use natural or mechanical ventilation at these locations. This practice will save electricity and maintain comfort.

If you live in an area where the electric utility system becomes overloaded in extremely hot weather you can help prevent a brownout by doing the following:

- Start your air conditioner earlier in the day or run it on the thermostat so you will not be placing the highest load on the system at the most critical time of the day.
- At times when a brownout may occur, it is better to leave the air conditioner operating on thermostat when leaving the house for periods of only several hours, rather than to attempt to cool the house on your return—unless expressly directed to do otherwise by your local officials.
- Raise your thermostat setting to the upper limit of the comfort range, say 80 degrees, during the period of highest load. For example, changing your thermostat setting from 75 to 80 degrees will reduce the air-conditioning load by 15% or more.
- As much as possible, reduce internal heat generation.

HOUSES WITHOUT AIR CONDITIONING

Insulate, Ventilate—and Take Advantage of Nature

It is possible to maintain a comfortable home in summer in many parts of this country without relying on a mechanical cooling system. As a matter of fact, many families do.

A number of the suggestions offered herein, while aimed at reducing air-conditioning loads, are perhaps more critically useful to families who do not use air conditioning.

It is practical in many areas to take advantage of the daily temperature cycle—to invite night's cool air into your home and to button up the house come the morning. The daily range of outdoor temperature is between 15 to 35 degrees and the lowest air temperatures usually occur from midnight to just before dawn.

In dry climates evaporative cooling can provide comfortable conditions both day and night at low cost. These devices evaporate water to lower the temperature of a stream of outdoor air circulated through the house. Evaporative coolers are of limited effectiveness east of the Mississippi River because of high summer humidity levels.

Many design and construction features for maintaining comfort are readily incorporated in a new house but difficult to apply on an add-on basis to an existing house. A new house can be oriented to take advantage of solar and climatic conditions. Rooms can be oriented accordingly—bedrooms, for example, might be located in the east so they will not receive the rays of the later afternoon sun. Building elements of large mass might be used to even out the daily indoor temperature cycle. In any event, professional advice might well be sought if you are planning to build. Meantime, here are some suggestions:

- When ventilating, draw in air from the coolest side of the house. Expel warm air from the upper parts of the house, either into the attic or through windows near their tops. A ventilator fan can be effectively installed into the upper ceiling to pull air through the house and push it into the attic. Or it can be situated in the attic to ventilate that space while pulling air through an opening into the attic.
- Take advantage of all possible ways of reducing solar heat gain; remember to draw the blinds and draperies of windows exposed to direct sunlight.
- Keep doors and windows closed during the day for as long as practical.
- Reduce indoor heat generation as much as possible; use exhaust fans in kitchen and bathroom, but only for as long as is necessary.
- Use small, quiet fans to provide the most satisfactory local air movement for the comfort of your family.

A thought- and action-oriented list of activities which individuals can undertake to help eliminate waste disposal problems in the home and community.

Solid Waste— Individual Citizen Action Check List for the Home and Community

CITIZENS ADVISORY COUNCIL
ON ENVIRONMENTAL QUALITY

Think About the Disposal Problem and Energy Factor of Every Purchase

- You'll conserve energy, reduce waste, and save money by buying beer, soft drinks, milk, and water in returnable bottles—and returning them. If returnables are not available or if they cost more, complain to the store manager.
- Look for long-life products, and avoid plates, cups, and eating utensils that are designed for one-time use.
- Consider using cloth instead of paper for towels, napkins, handkerchiefs, diapers. If paper serves a better purpose, insist on those products made from recycled paper.
- Cut down on items that are overpackaged by buying in bulk whenever possible, and then transfer them to smaller containers at home. This reduces the number of containers discarded and saves considerable money. Avoid individually wrapped slices of cheese and prepackaged fruits and vegetables. Complain to the manager if you are given no alternative.
- Avoid prepackaged and precooked foods. Cooking from scratch not only wastes less packaging but may cost you less as well.
- Avoid products packaged in plastics made from petroleum derivatives. Ask your butcher for paper meat trays and your grocer for paper bags in which to put your fruits and vegetables.
- Avoid products packaged in polyvinyl chloride containers (clear, semi-rigid, glass-like containers which frequently hold shampoo, hand lotion, mouthwash, and cooking oil). These petroleum derivatives give off poisonous fumes when incinerated.

- When environmentally good products come on the market, buy them and urge others to do so too.

Think About Reusing Items Around the Home

- Scarce paper can be saved by shopping with your own canvas or other reusable shopping bags.
- Use old newspapers to polish windows and tiles, to clean ovens, and to wrap gifts.
- Reuse old envelopes and both sides of stationery.
- Reuse gift wrapping paper and ribbons. Don't wrap presents that come in a box and don't use plastic tape which spoils wrapping paper for reuse.
- Share magazines with friends, or give to libraries or other institutions.
- Return metal coat hangers to your cleaner.
- Don't throw products into the trash heap when they still have a useful life. Take old furniture and clothing, as well as appliances and toys, to the Salvation Army, Goodwill Industries, or a secondhand shop.
- If you have a garden or backyard, keep your vegetables and fruit scraps, coffee grounds, and tea leaves, as well as your yard wastes, to make a compost pile.

Think About Assisting the Recycle Process

- Collect newspapers, cardboard, and clean paper for separate collection or personal delivery to recycle center.
- Use different colored containers to collect bottles, aluminum, and tin cans after removing tops and paper labels. Deliver to recycle center when convenient.
- Flatten cans and boxes, and crush other containers before discarding or holding for recycling collection. Ordinarily, 98 percent of the space in a full trash can is air.
- If there is no nearby recycling center, consider starting one. Write to Concern, Inc. (2233 Wisconsin Avenue, N.W., Washington, D.C. 20007) for its Recycling Center Plan.

Reduce Litter at Its Sources

- As a pedestrian, place candy, gum wrappers, empty cigarette packages, cigarette butts, and other disposable items in sidewalk trash receptacles. If local government doesn't furnish and maintain these, insist that it be done.
- In automobiles, carry a trash collection container, and use it and the ash tray.
- In the home, securely enclose garbage and trash put out for collection.
- Offices and commercial establishments also should use enclosed collection containers.

- Loading and unloading platforms should be well policed each day to eliminate litter.
- Trash collection organizations and companies that use open trucks to carry loose materials should keep such truck covered.
- Contractors at construction sites should provide and regularly service appropriate on-site receptacles for light construction refuse and for employees' lunchtime and coffee-break discards.

Encourage Others to Think About Waste and Energy Conservation

- In the marketplace, ask stores to carry returnable and reusable products and to foster the reduction of superfluous packaging.
- In the office, start a reuse, recycling program: use of both sides of stationery, separate collection of newspapers, scrap paper, boxes, and other paper products that can be delivered to a recycle center.
- In your community, encourage energy conservation through the reduction of solid waste and litter. Foster recycling centers. Encourage better community waste collection systems that are more efficient, save money, and that facilitate recycling and energy conservation.
- In your community, find out what stores, hospitals and other institutions are doing to encourage the recycling of their solid waste. Urge them to set an example for industry and citizens in the community. Reward them by telling the community what good things they are doing.
- Check on your local community disposal sites. Demand the closure of any open dumps.
- Investigate the solid waste practices of local industries. Urge improvement of measures that do not foster or facilitate recovery and recycling.
- Industrial executives and company owners, as responsible community citizens, can instill good solid waste management practices into the work patterns of their employees.

This check list was compiled from similar lists previously published by Concern, Inc., the League of Women Voters, and other sources. The U.S. Environmental Protection Agency is preparing other information materials along these lines. They will provide suggestions on ways and means to help neighborhood and civic groups stimulate and support better solid waste management at both the consumer and community level. For information on the availability of these materials, we suggest writing to the Office of Solid Waste Management Programs, U.S. Environmental Protection Agency, 1835 K Street, N.W., Washington, D.C. 20460.

Leisure time patterns have contributed greatly to our total energy use. These patterns and their relationship to ethical concerns and community facilities in terms of work-leisure flexibilities are examined in this article.

Leisure and the Energy Crisis

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In 1972 the oil producing and exporting countries (OPEC) raised the price of oil, with serious economic consequences for many nations. Gasoline prices in the US went up about 20 cents per gallon. President Nixon vowed that by 1980 we would end our dependence on those sources for our energy. Yet in the next three years, Congress established little more than a national speed limit of 55 miles per hour. A month before Jimmy Carter's inauguration, OPEC fell apart as a united force, with Saudia Arabia raising its prices by 5 percent, and the 11 other Arab producers by 15 percent. Prices to the consumer will continue to go up, and the Carter administration will, perhaps, succeed in developing a national program to develop indigenous resources and solar energy. Whatever the nature or success of new policies, the issues are closely related to issues of leisure.

No attempt need be made here to analyze the origins of the present crisis; indeed, that would take us into the history of energy depletion; the structure and power of the oil industry here and abroad, the recent Mid-East war, and the "Watergate influence" or lack of credibility. By now we may assume that the public has become aware of this background. Whatever the reasons, and whatever the smell of validity, the fact is that we are now driving slower; our homes are dimmer; our unemployment in affected industries is higher; our environmental gains of the past decade are under attack; serious restructuring of many plants, businesses, and educational institutions is under way, sometimes employing some variant of the four-day week. Although none of this has hit us as harshly as it has England and the Netherlands, there is now worldwide recognition of (1)

the interdependence of the technological and the social in our irrevocably complex society; (2) the importance now of examining priorities in personal life as well as in community and national policy; and (3) the necessity of better planning, not only for such technological fundamentals as sources and distribution of energy, but also for relationships between the means of life and the values toward which they are applied.

The area within this that I wish to examine is leisure. Unimportant, one might say, next to unemployment. Yet leisure patterns have contributed substantially to our total energy use—or misuse; and leisure will be at the heart of much that will be changed as the crisis intensifies.

In 1971, according to the U.S. Bureau of Mines, almost 65 billion gallons of gasoline were used by passenger cars.¹ According to the National Motor Sports Committee,² we use almost 9 billion gallons for recreational purposes, whether for vacation travel (the largest use), or for getting to and from a golf match (the smallest gasoline item).

The Motor Sports group is, of course, interested in demonstrating, for purposes of counteracting energy controls, how little we use for play purposes. But even their figures show that recreation takes about 13 percent of our total gasoline for passenger cars.

Since, if the crisis continues, much of this gasoline use may be cut, the Committee's listing of rank order for gasoline use provides an insight into American leisure—just before the energy crisis. In descending order of gas use, we get (approximately) vacation travel (59 percent), boating (9 percent), general aviation (9 percent), movies (7 percent), football (6 percent), basketball (3 percent), motor racing (1 percent), horse racing (1 percent), rodeos (1 percent), bowling (1 percent), baseball (majors) (1 percent), wrestling (1 percent), and golf (1 percent).

Obviously, there are other ways of using gasoline for leisure, such as going to adult education classes, to libraries, to visit friends, to parties, or to concerts. Much depends on how we define "leisure." If to all these we add volunteer activity in the community or attendance at club meetings, there is reason to think that gasoline consumption related to leisure is considerably more than 13 percent of the total.

If we peer into the figures and try to relate all these figures to the family next door, we can visualize (accurately) about 11 million neighbors who went skiing at least once in 1971 and spent more than \$45 million for skis alone. Or think of the neighbors who leave, sometimes every weekend, for a "second home" somewhere near good fishing or hiking; these homes now constitute a \$2-billion annual market.

Another clue to the energy crisis as it relates to leisure is television, which consumes about 3 percent of our total energy in the U.S.; the complaints about possibilities of gas rationing are a mere whimper next to the roar that the Energy Commission would hear if it tried (as they have in England) to cut out all television at 10:30 P.M.

The case of television turns us, then, to the question of how the energy crisis will, or might, affect our leisure—that is to say, much of our national life. For, of course, even though about 80 percent of our leisure pattern is

given to commercial entertainment, the *impact* of the current crisis will reduce much of that, and, therefore, enhance the possibility of noncommercial leisure experience.

The obvious change in leisure patterns will be felt in those areas directly dependent on us of the car. A reduction of 20 gallons of gasoline per week means 260 miles of city driving per week (we average, nationally, slightly more than 13 miles per gallon). To drive 260 miles in city traffic (averaging about 20 miles per hour) takes about 13 hours. However, we also spend time in whatever it is we are heading toward, such as the theater, a friend's house, the hospital, etc. Adding a conservative average of one hour per day for the substance or purpose of the trip, we have 20 hours per week that are eliminated from the normal city pattern by reducing gas consumption from 30 gallons to 10 gallons. Twenty hours are *freed* for new uses around the house or neighborhood. The accumulation of leisure time since the turn of the century has been great:

Let us assume that in each of the years since 1850 we spread our work week over six days. Let us further set aside seven hours each 24-hour period for sleep, an hour for eating, and two hours for other activities more or less essential. What does this actually permit us in each period for doing pretty much what we want to do? About 2.18 hours in 1850, compared to 7.48 hours in 1960.³

Thus, the free time created by 20 gallons of unused gasoline in the urban scene comes to 35 percent more leisure time than the *total* of free time in a six-day period of 1850; and it is an addition of 40 percent to the 1960 level of discretionary time.

This gives us a rough, but dramatic impression of how large the amount of leisure time is—not the *whole* of it, but just that part of it freed up for re-channelling by the energy crisis on a weekly basis during one's work year (not during vacation trips).

Ethical issues are also involved. Consider the area of leisure as an ethical matter in an energy crisis. Florida had over 25 million tourists in a recent year, and, therefore, its first business as a state relates to a vast apparatus, linking gas stations to highways, to motels, to the building trade unions, to the banks, to the gambling institutions, to Disney World. How are we to balance the need to avoid statewide economic decline against the overall need to save gasoline?

The crucial issue that joins the energy crisis and leisure is one of essentiality vs. discretionality. That is, what is of the essence, and what is more of preference? Whatever else leisure may be, certainly one of its major elements is that of freedom: economically, freedom from work; psychologically, freedom from routine. Ethical problems relate to both, and indeed the sociologist Robert Havighurst refers to both the work ethic and the leisure ethic, and his analyses lead him to the important conclusion that both work and leisure function toward similar ends, such as a meaningful existence.⁴ Yet the ethical issues of the dimensions of work and leisure are distinct, and, indeed, it may be precisely the ethical choices

and values that provide their fundamental distinction. The present issue takes its shape from the word *crisis*, not from *energy*, for a major point to be made is that the new "lifestyles" that may result from a diminution of oil and gas already have strong antecedents; i.e., the trends in leisure, while deeply affected by physical movement (as in tourism), also include other directions such as creative self-discovery. The present "crisis," sparked by the Mid-East war and oil as a new technique of international blackmail, has pushed some ethical considerations related to lifestyles and leisure up perhaps a quarter to a half century.

Ethical problems, we like to think, center in our values as individuals. The other problem is that of alternatives from which we make our choices. Here the community takes over, for it is not the individual who builds football stadiums or bicycle paths. Nor, as in the several English crises, does the individual decree a three-day work week.

I now move toward the matters of community facilities and work-leisure flexibilities.

The energy crisis focuses attention on the community as a place to "work" and a place to "live." These terms are not as consonant as the work ethic has historically made them out to be; but in a reversal of history, each community—with a diminution of discretionary transportation—becomes again a unique place, apart from other communities. Indeed, on three levels, the American community finds a unique opportunity in the energy crisis relative to the "living" aspect.

First, it needs to study its present facilities for absorbing the time freed by the reduction of the 20 hours of driving per adult. The problem is conceptual—what should be included? A realistic scope will include all the outdoor and physical activities (tennis, golf, parks, beaches, stadia, bicycle paths, etc.), the arts (as audience and participatory opportunities), education (especially for adults, and including such opportunities as classes, libraries, the mass media, and book stores as decision contributors), opportunities for volunteer services, and, not the least, the city itself as a place for adventure (the outdoor mall, the zoo, the interesting neighborhood—the Prater of Vienna, Marguarite Island of Budapest, or Chinatown of San Francisco).

A second task for the community that seeks to confront its opportunity in the leisure crisis is to anticipate new patterns in leisure conduct. Since there is little to go on as to the prospective "end" of the crisis or, indeed, whether such an "end" will be recognizable, a major issue is whether there will be a carry-over into permanent leisure patterns in subsequent years or decades. Will the reading by a new library client "catch on"? Will the new neighborhood club continue to meet? Evidence from the past seems to indicate that permanent change may be expected. There are few, if any, examples of communities that have sold their public parks or of mass movements by workers to return to work on Saturdays. The trends are quite the reverse. Japan's workers have been breaking away from intense loyalty to large companies (formerly indicated by their lounging in the factory when off-duty) and moving away from home with

new cars or on their excellent public transportation. Perhaps one answer as to how permanent the emergency programs will become will depend on the excellence of those programs.

Finally, the community can use the energy crisis to call public and official attention to the need for enlarging and improving present facilities and services—library hours, playground and park facilities, museums, youth activities, special programs for the elderly, and so on.

An interesting impact of the energy crisis may be seen in the restructuring of work itself. On many jobs time schedules are monuments to the past, given the necessity that many workers must be able to communicate with others—the store clerk with customers or the wholesalers with the retailer. Companies that have moved to the four-day work week have had to consider these external, as well as internal, issues. Yet, as many manufacturers and businesses of Europe are discovering (especially in West Germany), there are numerous workers (clerks, editors, hand tailors, accountants, etc.) who can carry on most of their work at home. Or, keeping the office or plant as the major base of work, the "flexitime" development permits the individual to fulfill his assignment on any time plan she/he prefers within the 24-hour day or during the week.

The utility of such flexibility in work is apparent for partial resolution of the energy crisis. Simultaneously, leisure actions are directly involved. Indeed, the four-day work week may more realistically be called the three-day weekend; this brings us closer to motivations in the change. Riva Poor's *4 Days, 40 Hours*⁵ is reportedly being carefully reread by many in government and business circles in the United States. It will, perhaps, take the energy crisis to convince many industrial managers that the worker is less bored and a better employee when she/he has some control over her/his rhythm of work-leisure. Executives have become work fanatics as a breed and cannot be expected to understand the nature of boredom at work for others, as attested to by (a) their surprise at increasing boredom at GM and other centers of impersonal work tasks, and (b) their own incapacity to use free time, as reported by Sebastian de Grazia or by observers of pre-retirement planning.

Crisis, we must remind ourselves, is not always synonymous with misfortune. As the *Random House Dictionary* (1969) defines it, crisis is "a stage in a sequence of events at which the trend of all future events is determined"; a "turning point." In that sense getting married or obtaining a college degree is a crisis. To have gasoline rationed is unpleasant and confining; to make friends with a neighbor because of it may be rewarding. Behavioral semantics is not my intention, lest it appear as the Victorian maxim about watching for the "silver lining." Yet, as there are certain businesses that will gain from the energy crisis (aside from the oil companies), so there will be effects on daily life that are not bad; fewer cars on the highways or streets may even diminish air pollution and save lives.

Aside from bidding us to look ahead toward positive policy to utilize the imminent possibilities, the "crisis" also provides a perspective from which we may see that new leisure patterns have been in the wind in the

United States and in all industrializing societies. We shall hardly cope with the opportunity now open to us without this recognition of the worldwide dimensions that leisure has assumed during the past few decades, and the considerable amount of knowledge—increasingly systematic—that already exists among a new group of scholars. And perhaps in time, a new discipline and new private/public policies for both leisure and energy use will mature in the post-industrial society.

Notes

1. *American Almanac, U.S. Book of Statistics and Information*. New York: Grosset & Dunlap, 1973. Table 891, p. 541.
2. Motor Sports Marketing Corporation. *Leisure Time Activities Energy Consumption Report*, 1973.
3. Kaplan, Max. *Leisure in America*. New York: John Wiley & Sons, 1960. P. 38.
4. Havighurst, Robert. "Life Styles and Leisure Patterns: Their Evolution Through the Life Cycle." *Leisure and the Third Age*. Paris: International Center of Social Gerontology, Third International Course of Social Gerontology, Dubronvik, 1972.
5. Poor, Riva. *4 Days, 40 Hours*. New York: New American Library, 1973.

Are new energy sources really saving us energy? This article discusses the phenomenon of "Net Energy" in relation to new and developing energy technologies.

Net Energy: Figuring the True Yield

A Science/Society Case Study

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The energy crisis has focused attention on U.S. and world supplies of energy resources. Whereas in the past plentiful energy resources were readily available, impending shortages now spur searches for new ones. Since these new resources—whether fossil and nuclear fuels, solar, tidal, or geothermal—are generally less easily obtained and often require special technology, the concept of *net energy* becomes increasingly important. Net energy refers to the energy left after all the energy inputs required to find, recover, process, transport, and alleviate pollution from an energy resource have been subtracted. As the examples below will show, energy inputs may result in a significant reduction in the value of the resource.

The Old Subsidizes the New

The development of energy resources is a history of new technologies building upon older ones. For example, coal mining provided the basis for the Industrial Revolution, but the first coal mines required machines and tools whose materials and operation depended on energy supplied by wood and charcoal. Eventually, as more coal was mined, energy to manufacture the iron and steel used in mining machinery and to operate this machinery began to be obtained from coal; clearly a significant portion of the energy resource (coal, in this case) was spent just getting it out of the ground. Thus, net energy was well below 100 percent of the resource.

Development of other fossil fuel resources (petroleum and natural gas) was originally subsidized by energy derived from coal, but now these fuels

are also "self-supporting." Nevertheless, 5 percent of current U.S. consumption of energy resources is required to produce and refine petroleum, which supplies about 43 percent of our total needs. Thus the net energy available from petroleum is well below 90 percent¹ of what is pumped from oil wells. If we include in our calculation the fact that current methods of production leave about two-thirds of the petroleum in the ground, net energy drops to about 30 percent of the total energy available in the formation. Further, if the petroleum is burned in an electric power plant (average efficiency about 33 percent), net electrical energy amounts to only 10 percent of the original resource. And if the petroleum is burned in an automobile engine (less efficient even than a power plant) net energy is even smaller.

Some technologies suggested as solutions to the energy crisis may produce little or no net energy and may therefore be of little value. Nuclear fusion power—in its current state of development—is an excellent example; more energy is required to initiate a fusion reaction than is released when the reaction occurs. Of course, future technology may overcome this problem, and the large quantities of energy which might eventually become available are an adequate reason for continuing fusion research. The important point, however, is that unless the net energy concept is applied to a new resource, we may grossly overestimate its potential, and since development of a new resource must be subsidized by older ones, the danger exists that an imprudent choice might further deplete supplies of fossil fuels instead of supplementing them.

One further point of interest: the net energy concept also influences the rate at which a new technology may be adopted. Consider, for example, nuclear fission power plants (described in this column in October and November 1975). There is no doubt that fission power does yield net energy, but two major energy inputs are required: fissionable²³⁵ U must be separated to serve as fuel, and large power plants (which include numerous unusual alloys and other products of high technology) must be constructed. Obtaining fissionable uranium may be thought of as the energy cost of operating the power plant, while power plant construction is a one-time capital investment of energy, the *sine qua non* of new production.

Energy to provide for this capital investment must come initially from fossil fuels. Furthermore, the number of new nuclear fission power plants that can be constructed each year clearly depends on the fraction of fossil fuel (and eventually nuclear) energy resources that can reasonably be diverted from other ends. Like the net energy concept itself, this problem becomes more and more important as less readily available energy resources requiring more highly developed technology begin to be considered. Some observers have suggested that the rates of expansion of nuclear power projected by the Energy Research and Development Administration may be unrealistically large on this basis.

¹(43%-5%/43%) × 100%

Energy Conservation

One approach to solving the energy crisis which makes good sense from this point of view is energy conservation. (Actually the term "energy conservation" is redundant; energy is conserved in the natural world whether we want it to be or not. What we really want to conserve is energy in forms which can be harnessed to do useful work. In the case of chemical and biological systems, such energy is referred to as *free energy*. Although teachers may wish to point this out to curious students, it seems unlikely that the terminology "free energy conservation" will catch on in ordinary speech.)

As an example of the advantage of conservation over development of new energy resources, consider the petroleum-fired electric power plant mentioned earlier. A savings of 1J in electrical energy translates into 10J of untapped petroleum reserves in the ground. On the other hand, if the petroleum is just not there and we are forced to turn to a new nuclear fission power plant, the first 1J of electrical energy will be quite costly. Many years will be required to amortize the capital energy investment in the new power plant, and until this is done its energy cost will be high.

Student Involvement

The net energy concept leads nicely into classroom discussions of relatively simple steps that can be taken to conserve free energy. A recent U.S. government study [4] suggested the following measures as having reasonable probability of being carried out in the near future:

- Improve insulation in homes
- Adopt more efficient air conditioning
- Shift intercity freight traffic from highway to rail
- Shift intercity passenger traffic from air to ground
- Shift urban passenger traffic from automobile to mass transit and consolidate urban freight movement
- Introduce more efficient industrial processes and equipment

Many of these have already been adopted to a limited extent, but we can go much further. Understanding the net energy concept should be of considerable value to students in making decisions about energy conservation and the development of new energy resources.

Suggested Readings

The concept of net energy is not widely and easily available in the literature. However, we suggest the following as good starting points:

1. Robertson, T. A. "Systems of Energy and the Energy of Systems." *Sierra Club Bulletin* 60(3):21-23; 1975.

2. Miller, G. Tyler, Jr. *Energy and Environment: Four Energy Crises*. Wadsworth Publishing Co., Belmont, Calif. 1975. (Well-written, very useful.)

3. Council on Environmental Quality. *Energy and the Environment: Electric Power*. August 1973. (Available for \$1 from Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402, stock no. 4111-00019. A readable and thorough treatment.)

Good sources on energy conservation in addition to reference 2 are:

4. Executive Office of the President, Office of Emergency Preparedness. *The Potential of Energy Conservation*. October 1972. (Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402.)

5. Massachusetts Institute of Technology. *Technology Review* 76 (4): February 1974. (The entire issue is devoted to energy conservation; highly recommended.)

Guidelines for designing energy education programs and for the preparation of energy materials for American school systems are presented in this article.

Some Guidelines for Energy Programs

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The Carter Administration's attempt to forge a national energy policy has generated an increased interest in energy education. How long this interest will continue and whether or not it will be strong enough to have any lasting effect will depend upon the answers to several questions. Chief among these are (a) Will the federal government provide significant, long-term support for energy education projects? and (b) Will teachers and administrators draw upon what is already known about this field to respond creatively to such support?

That the schools have an important part to play in the country's energy future cannot be doubted. One of the fundamental principles of President Carter's energy plan is that the country can have an effective national energy policy "only if the government takes responsibility for it and if the people understand the seriousness of the challenge and are willing to make sacrifices." This statement contains an implicit challenge to educators, who must help the public understand energy issues. It is, of course, important for all citizens to be informed about these issues, but it is even more important for tomorrow's voters and decision makers—students in today's classrooms—to know about them.

Several programs already developed in energy education give reason for hope about the future of this field. For example, in the early months of the energy crisis, the National Science Teachers Association (NSTA), with assistance from USOE's Office of Environmental Education and the Federal Energy Administration, began to develop background readings and source materials on energy for teachers. The NEA recommended teachers to review these materials.

More recently, under a grant from the Energy Research and Development Administration (ERDA), NSTA began to develop teacher-written, interdisciplinary energy packets for use in the classroom. Teacher-writers, working with the NSTA staff, produced these packets during summer energy curriculum workshops. The NSTA/ERDA effort is proving that government-sponsored programs operating in cooperation with state and district-level supervisors can help bring an understanding of our national energy situation to the classroom.

Another project, the now-defunct Interstate Energy Conservation Leadership Project (IECL), was sponsored by the U.S. Office of Education and administered through the Colorado Department of Education. In its two years of existence, the IECL project, with a budget of slightly more than \$100,000, sponsored nine national conferences and more than 30 workshops on energy, established and operated an energy education clearinghouse, published an energy newsletter, sponsored a national energy conservation contest for school districts, and published a series of practical "how-to" booklets on energy conservation for educators.

Another energy education program is Energy and Man's Environment (EME), a project created to encourage the introduction of energy-environment themes into the school curriculum. Operating in most Western states, EME has the distinction of being supported almost wholly by utilities companies. Whether this distinction will prove to be an asset or a liability remains to be seen, but in the meantime, EME is expanding its program in the West and is developing a reputation for working well with teachers and with established educational agencies. EME is producing materials and has come out with a set of activity guides.

From these and similar experiences have emerged some guidelines that those who attempt to design programs in energy education should keep in mind. They are as follows:

Energy education should be aimed at teachers as well as at students. Textbooks and other materials on energy, no matter how good they are, can only be as effective as the teachers who use them. Teachers interested in this subject must have the opportunity to learn about energy basics and some of the methodologies that are appropriate to energy as a subject area. Therefore, funds should be spent for teacher workshops and other in-service training programs in energy education. Moreover, teacher education institutions should be encouraged to include energy in their programs. The faculty development projects, recently initiated by ERDA, are a step in the right direction.

Assuming that the government is serious about supporting energy education, teachers and administrators must be prepared to translate any assistance into effective programs. This preparedness involves several steps, including the following:

1. Keeping informed about the world energy situation. This means more than just reading articles about energy in the daily paper. Those in charge of energy education programs need not be energy experts, but they must

know the basic information concerning supply and demand, major consumption patterns, alternative energy sources, and so on.

2. Seeking the highest possible level of support for energy education programs in state, school district, or building.

3. Being aware of the resources for teaching about energy that exist in your state, region, and school district. These will include people, places, and materials outside the educational community, as well as administrators who have an interest in the subject and teachers who have already introduced energy into their courses.

Successful energy education programs require time and money. The President has said that we are engaged in "the moral equivalent of war." Let us hope that education, in fighting its part of this war, will not have to settle for the moral equivalent of money.

Most financial support for energy education projects has been sporadic and insufficient. The thinking seems to have been that the energy crisis was a temporary inconvenience. But time has taught us that what we call "the energy crisis" is, in reality, a multifaceted and long-term problem. Educational strategies designed to meet the challenge must be created with this fact in mind, and funding for energy education programs must be on something more than a hand-to-mouth basis.

Most students spend 12 years in school. They need energy education throughout all those years, and this will not come cheaply.

A related point is that an alarmist approach to energy education does more harm than good. Facts learned for the sake of averting a crisis are quickly forgotten when the promised disaster fails to erupt on schedule or fails to produce the predicted consequences.

In addition to these guidelines for designing energy education programs, guidelines for preparation of energy materials have also emerged. They are as follows:

Energy materials for classroom use should be written by teachers, or at least in close consultation with them. There are several good arguments for this practice. First, although there is a wealth of material on this subject, most of it must be modified for use in an existing course of study. Teachers are the best source of ideas on how to accomplish this.

Second, many energy materials, regardless of how accurate or up-to-date, treat national concerns and ignore regional problems. When teachers create or adapt materials, they can add the regional or local information.

Energy materials, like materials on other subjects, should recommend many activities. Energy, itself a process, lends itself especially well to activity-centered learning. For example, more can be learned by building a simple solar collector and experimenting with it than by just reading about one. And students can better understand energy sources, conversions, and uses, when they not only read about these things but also work with them in simple bulb-and-battery experiments.

Energy materials should be designed to fit into the existing curriculum. Because the topic is related to almost everything we do, it has applications in a wide range of teaching activities. For this reason, energy should be thought of as an integral part of the curriculum rather than as an "add-on" teaching assignment.

Energy's broad and complex scope is, at first, rather intimidating. But this very quality is also the subject's greatest asset. Because of its breadth, the energy topic can be used to help students grasp the relationships between specific areas of a specific subject or between areas of concern shared by different subjects. For example, the technology of energy is a legitimate concern of both the history teacher discussing the Industrial Revolution and the science teacher dealing with the laws of thermodynamics.

Energy materials should be designed in a wide variety of disciplines in addition to science, including the humanities and the social studies. Traditionally, energy education has been left to science teachers. Since the energy crisis began, however, teachers of other subjects have become aware that energy concerns their areas, too. For example, a question dealing with the effect of American energy demand on foreign policy is a natural for many social studies classes.

Although some states, school districts, and individual schools have developed good energy education programs, these usually get little or no national publicity. The unhappy result is a wasteful duplication of effort throughout the country.

Greater effort is needed to locate good materials and to make them available to teachers in a useful form. A national newsletter would help spread information about both promising programs and available materials.

If the brief history of the energy crisis has taught us anything, it is that time is crucial. Much has been done in energy education, but greater progress must be made. This will call for the patience, persistence, and cooperation of both those who can provide financial and technical assistance and those who understand the diversity and complexity of the American school system.

Background Reading

Continuing Energy Crisis in America. John L. Moore, editor. Contains good background information on conservation, energy economics, alternative energy sources. Congressional Quarterly. 1975. 125 pp. Available from Congressional Quarterly, Inc., 1414 22nd St., N.W., Washington, DC 20037. \$5.25.

Energy-Environment Source Book. John M. Fowler. Designed especially as a teacher resource. Contains information on the social and economic implications of the energy crisis as well as technical and statistical materials. NSTA. 1975. 270 pp. Available from NSTA, 1742 Connecticut Ave., N.W., Washington, DC 20009. \$4.

Energy Dilemmas: An Overview of U.S. Energy Problems and Issues. An excellent, brief, up-to-date summary of the major energy issues confronting the United States. Contains a good bibliography. League of Women Voters Education Fund. Publication #688. 1977. 39 pp. Available from The League, 1730 M Sts., N.W.,

Washington, DC 20036. Single copies, \$1; 5-9 copies, 80¢ each; 10-49 copies, 70¢ each; 50 or more copies, 60¢ each.

Energy Options: Examining Sources and Defining Government's Role. Covers the major energy sources and alternatives to the fossil fuels. Explains how reserves are determined, how exponential growth is calculated, and the roles of various federal agencies concerned with energy. League of Women Voters Education Fund. Publication #628. 1977. Available from the League. See preceding entry for address and price information.

Energy: The Solar Prospect. Denis Hayes. Describes direct solar heating and cooling; electrical generation; wind and hydroelectric power; biological sources, from farming of "energy crops" to anaerobic digestion processes. 1977. 79 pp. Available from UNIPUB, Box 433 Murray Hill Station, New York 10016. \$2.

Factsheets. John and Kathryn Fowler. A series of 19 four-page factsheets on alternative energy technologies. Titles include "Electricity from the Sun" and "Geothermal Energy." NSTA, 1976. Single copies available free from ERDA, Technical Information Center, P.O. Box 62, Oak Ridge, TN 37830.

Curriculum Materials

Award Winning Energy Education Activities. A collection of winning entries in an energy curriculum development contest. Contains lessons for grades K-12. NSTA. 1977. 40 pp. Single copies available free from ERDA, Technical Information Center, P.O. Box 62, Oak Ridge, TN 37830.

Energy and Conservation Education Activities for the Classroom. Energy activities for grades K-12. EME. 1976. For a price list, write to EME, 0224 S.W. Hamilton, Suite 301, Portland, OR 97201.

Energy Curriculum Packets. Interdisciplinary energy units written by teachers. Titles include "The Energy We Use" (Grade 1), "Energy, Engines, and the Industrial Revolution" (Grades 8-9), "Transportation and the City" (Grades 8-9), "Agriculture, Energy, and Society" (Grades 10-12). NSTA. 1976. Single copies available free from ERDA, Technical Information Center, P.O. Box 62, Oak Ridge, TN 37830. (By the time this article goes to print, NSTA will have eight to 10 new units available for trial use and review. For free single copies of these draft materials, write to "Energy Units," NSTA, 1742 Connecticut Ave., N.W., Washington, DC 20009.)

Energy-Environment Materials Guide. Kathryn E. Mervine and Rebecca E. Cawley. An annotated guide. NSTA. 1975. 74 pp. Available from NSTA, 1742 Connecticut Ave., N.W., Washington, DC 20009. \$2.

Energy-Environment Mini-Unit Guide. Stephen Smith, editor. Activities for grades K-12. Contains directions for the teacher, materials for student use, and suggested ways to evaluate student achievement. NSTA. 1975. 220 pp. Available from NSTA, 1742 Connecticut Ave., N.W., Washington, DC 20009. \$3.

The Energy Challenge. A set of suggested activities together with ready-to-use spirit masters for grades 5-8. Topics include energy supply and demand, energy conservation, and possible energy sources of the future. Federal Energy Administration. 1976. Single copies available free from the Energy Challenge, Box 14306, Dayton, OH 45414.

Developing an awareness of the various energy alternatives is extremely important in energy education programs. To help solve this problem the author proposes community energy teaching centers designed to enable the curious to encounter and explore energy alternatives such as solar hot water systems, solar cooking units, wind-generated electricity, etc. The centers would involve schoolchildren, parents, homeowners, and teachers.

Energy Teaching Centers

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That New England has been one of the areas hardest hit by the energy crunch is no secret. In addition to immediate problems, the region faces long-term troubles, including a decrease in numbers of jobs and fewer incoming industries because of projected high costs and low availability of energy resources. In reaction, many New Englanders are experimenting with alternative energy resources. The New Hampshire state legislature, for example, recently enacted legislation enabling towns to grant tax reductions for homes incorporating solar and other energy systems which are not dependent on fossil fuels.

The local situation thus focuses community attention on specific aspects of the energy crisis, and spells out the enormous need for energy education—not only for youngsters, but also for members of the adult community, who are curious to encounter and explore energy alternatives. For these reasons, I propose the initiation of community Energy Teaching Centers.

The centers I envision seek to involve three distinct populations: school children, parents and homeowners, and teachers. Even with such diverse target populations, good educational practices call for certain fundamental approaches. Each center should offer:

- Working units of alternative energy technologies;
- Hands-on experience in construction and operation of resources;
- Translation of theories and concepts into practical and immediate application;
- Print, media, and human resources.

The most reasonable place for any educational campaign to start is with energy conservation. For students, this could be related to the school, giving background knowledge about how the school heating plant works, costs, and points of origin and recovery of fossil fuel resources. Science and social studies subject matter could be explicitly related to energy concerns and practices. For example, principles of heat transfer could be applied to such topics as heat loss through building glass and the layered look in clothing; $W = I \times E$ calculations in a study of electricity could be used to assemble a "Ten Most Fuelish" list of electrical gadgetry. Copying wattage or amperage rating plates from appliances are activities which are bound to filter into some homes and begin to raise the awareness of parents.

Indeed, when one begins to look at content from an energy perspective, few areas of the curriculum are left untouched. "Home Chores 200 Years Ago, 100 Years Ago, and Today," "Factory Power Since 1700," "Heat and Light for 200 Years," and "Transportation Since Colonial Times," are only a few interdisciplinary topics already in most curricula, albeit in some other form. The scope, depth, and general complexity with which such topics are treated can, of course, be governed by the level of the audience.

Energy conservation activities for adults must focus on their special concerns. During the gasoline crisis a Boston radio station ran a fairly successful "Commuter Computer" carpool program—a good idea which deserves to be extended. Discussions of home insulation techniques and materials could easily fit into adult education programs, club meetings, or evening workshop sessions. New Englanders are also interested in safe ways to install and use supplementary wood-burning heaters. Both topics can be handled by local resource people—contractors, architects, and U.S. Forestry Service personnel, for example. These special topics, along with others determined by community interest surveys could provide the impetus for a strong, large-scale energy conservation effort—especially when combined with activities brought home by school children.

Teachers as homeowners would certainly attend some of the workshops held for the general adult community; however, they have special needs, too. New Hampshire has an ongoing staff development program in every school district—a logical mechanism for determining special interests among teachers and establishing workshop program.

One important function of the Energy Teaching Center would be to coordinate existing vehicles for reaching target populations. In this capacity the Center could conduct surveys to determine perceived needs and interests, then convey that information to local agencies. To further assist agencies to meet identified needs, the Center should serve as a resource clearinghouse: Files of resource people, industries interested in hosting tours, and private homeowners willing to open their energy-saving ideas to public view would be useful to a broad spectrum of civic and educational groups. The Center could also house print and media resources, making available energy publications, a file of teaching activities and references, and film and videotape programs of local projects (as well as

commercially produced programs of general interest). Activity boxes for classroom and club use could furthermore be assembled and distributed on loan. Ideally, the Center should also serve as a dissemination agency for news releases, a weekly newspaper bulletin, and for information about contests, shopping mall displays, etc. The center is also a logical community meeting place for small groups.

Exploring Alternatives

The best way to explore the possibilities of alternative energy technologies is to put them to work. Some obvious criteria for selecting demonstration models for a Teaching Center are: (1) ease of construction and operation, (2) successful operation, (3) ready applicability to the home, and (4) reasonable cost. These criteria are by no means meant to preclude demonstration of those principles which have not yet been reduced to simple, practical application; however, information on such units should make it clear why they are not yet feasible for common use. Among the items I would include in this latter category are solar voltaic cells (the *Skylab* panels, for example) and parabolic cookers, such as that described by D. S. Halacy, Jr. in his *Fun with the Sun*. A survey of available, feasible alternative energy technology yields the following possibilities:

- Solar hot water systems for domestic use
- Solar cooking and food preservation units
- Methanol as a gasoline additive or substitute
- Wind-generated electricity
- Bio-gas
- Passive solar heat.

Solar hot water systems are readily available commercially. Those Centers interested in demonstrating such systems should put the project out to bid with these construction specifications: The system should supply all or part of the hot water of the Center, utilize commonly available supplies where possible, and incorporate accessible working parts for purposes of teaching and monitoring. Collector units could be installed on the roof of the building housing the Center and made accessible by catwalks. Installation and minor construction would provide a one-time but important opportunity for community participation. A solar hot water unit is likely to be of great interest to homeowners and also offers science classes a number of possibilities for monitoring and demonstrating scientific principles.

Solar cooking units could also be placed in a rooftop complex; however, problems of accessibility in winter must be considered. These units are simple to construct, making them ideal workshop projects for all target groups. They offer myriad possibilities for experimentation once the units are complete.

Also, preserving food by drying it in the sun is an ancient and essentially fuel-free process. The apparatus is quite simple to construct, and food preparation and storage information is plentiful.

Methanol as a gasoline stretcher or substitute has been in use for quite some time. Necessary carburetion adjustment information is readily available, and methanol is a renewable resource. Maine has a large ongoing project which would be valuable to an energy teaching project in New England. The logical set-up for a practical, working demonstration unit is a small gasoline engine with a dual fueling system and a selector switch for gasoline or methanol. Though a four-cylinder automobile engine would be ideal, considerations of weight, exhaust, and space may dictate use of a smaller engine. This unit would also make pollution studies possible.

Wind-generated electricity is another practical energy alternative in service for some time. Current drawbacks are: size of the unit, lead-acid storage systems, and problems of providing smooth, constant power. If interest is sufficient, a small (but expensive) unit could be installed. There are firms in New England which could handle the specifications for a teaching unit, and its installation would provide an opportunity for community participation. (There is, after all, educational value in showing why something is not broadly feasible.) Perhaps the creativity for solving the problems lies, as yet untapped, in the community. In any case, teaching implications exist for geography, meteorology, climatology, electricity, and so forth. As a bonus, the output of such a unit is likely to be sufficient to power some of the Center's instrumentation and demonstrators.

Bio-gas is an ecologically sound energy alternative, already successfully demonstrated in other parts of the world. The principal drawbacks for installing it in a teaching center are the raw material requirements and the problems of storing a highly explosive gas. However, the process does have promise. There is a wealth of information on large-scale operations, from India's Gobar Gas Research Station, to Rodale Press's *Organic Gardening* demonstration farm, and L. John Frye's work in South Africa. I use a demonstration unit in my classroom. The residue is an excellent fertilizer, and the various stages of the process involve a number of biological and biochemical factors. The small amount of residue from such a unit could supply plant tables, as well as material for experiments in microbiology and chemistry.

Passive solar heat is best illustrated by a greenhouse; the problem is holding the heat and transferring it efficiently to other parts of the building. If the Center has a greenhouse, such a facility is a logical place to start. Various means of trapping, storing, and transferring heat could be investigated.

This list should certainly not be considered complete. Education and energy technology continue to develop, change, and grow and the Energy Teaching Center I propose would constantly evaluate programs and sample community concerns.

How would groups use the Center? Tour features could include eating solar-cooked minifranks or solar baked Yankee cornbread, and apple pie

from sun-dried apples; drinking methane-brewed beverages; riding on a methanol-powered go-cart; and taking a quiz on an answer board operated on wind-generated electricity. The tour group could wash for lunch in solar-heated water and view a film on energy in a solar-heated room. While these ideas may sound rather flashy and contrived, demonstrations of this sort have a place in motivation and awareness-raising. They smooth the way for more study.

The serious and detailed study which could be supported by the Center is limited only by the creativity and insight of Center personnel and community members. If the Center were regularly staffed, students could be scheduled to participate in activities related to classroom work. In fact, while any building (or part of one) could be easily adapted to house the Center, a school would be the logical building to maximize student access. Schools are furthermore often flat-roofed and located in wide, open spaces convenient for solar and wind units.

A large number of details concerning logistics, administration, finance, and personnel are deliberately omitted from this proposal. The broad structures indicated here would become more specific as an interested community adapted the features of the proposal to its own priorities and capabilities. A more clearly defined, local proposal would most likely be eligible for funding under a number of federal programs, notably the Environmental Education Act, Career Education, and various Elementary and Secondary Education Act (ESEA) titles.

Energy comes from many different sources. This article describes and examines both the renewable and nonrenewable sources such as petroleum, natural gas, coal, geothermal, solar, wind, and electrical energy. Also included are several energy-related projects for students to undertake as well as a useful glossary.

Where Does America Gets Its Energy? —Energy Conservation Activities for Young Learners

OFFICE OF CONSERVATION EDUCATION,
FEDERAL ENERGY ADMINISTRATION

What Is Energy?

We hear a lot about energy these days. Energy is very important to all of us. We use it in many forms each day. We can't see it, but we can see and feel what it does.

The word "energy" can have a number of different meanings, but here will be used as it is by scientists and engineers. It will be closely associated with two other words which have special meanings to the scientist: "work" and "power."

The scientists says we do "work" when we push or pull something for some distance; "energy" is the capacity to do work, that is, the ability to make something move; and "power" is the rate at which energy is produced or used.

When you raise your arm you use energy. The bus going down the street and the plane flying overhead are using energy. The energy we see in the motion of objects is called "mechanical energy." But energy exists in many less obvious forms. *Heat* is a form of energy, and so is *electricity*. *Chemical* energy holds materials together, and the water behind a dam or a rock on the top of a cliff are forms of *potential* energy.

All these forms of energy are useful to us because we can store energy in one form, transform it to another, transport that from place to place, and then transform it again to do work for us. For example, coal stores chemical energy. It can be burned to make heat energy. Heat can run a generator to make electrical energy. The electricity passes over wires to run a motor and the motor can beat our eggs.

You can see how important energy is. But, is there enough energy to do all the things all the people on earth want?

The fact is that most of the energy we use today in the United States comes from oil. The world has a 30- or 40-year supply of oil left; most of that is in foreign countries, and its price has risen sharply. What will we do when we run out of oil?

An average person in the United States uses as much energy as 25 people in some other countries, such as China. All of those billions of people would like to live as well as we do. Could we possibly find enough energy to meet all their needs?

A Project To Do: An Energy Chain

Select any item you can see in your home, school, or street. List the kind of energy associated with it. What energy makes it run? Does it transform energy from one kind to another? Does it store energy? What kind? What kinds of energy were used in its manufacture? What energy do you need to use it?

Write a one-page essay describing the energy chain associated with the object you chose.

Where Does Energy Come From?

Fossil Fuels

Millions of years ago, plants lived and died in forests and swamps which covered parts of the earth. New plants grew and died on top of others, and this chain of growth and decay formed a rich, soft material that looked like rotted wood. Over millions of years, the earth's surface sank, and water from the oceans rolled over the layers of rotting plants. The immense pressure and weight of the water, plus heat and bacteria, changed the rotting plants into "fossil fuel"—coal, oil, and natural gas.

Petroleum

One of the most important fossil fuels is petroleum, or crude oil. Oil is trapped in porous rock beneath the surface of the earth. To find it, we must often drill thousands of feet. Drilling rigs can be set up on land or in the ocean, wherever oil can be found. Taking oil from where it is discovered, however, requires a great deal of human and machine energy. At the present time, we don't produce enough oil in our country to fill our energy needs and must import *one-third* of our oil from foreign sources.

Every day we use products made from crude oil. Some is used as heating oil to keep our homes, apartments, and office buildings warm. Some is used as gasoline and motor oil for our automobiles, trucks, and buses. Kerosene for jet aircraft, diesel fuel for trucks and machinery, and asphalt for our roads all come from petroleum.

Oil is also used as a feedstock, or raw material, to make new products and conveniences. The plastics industry uses petroleum to manufacture packaging, furniture, and toys. Man-made fabrics, such as nylon, have been developed from petroleum. Even some medicines are derived from petroleum, as are many chemicals and fertilizers.

Natural Gas

Natural gas is the cleanest burning of the fossil fuels. It is usually the most convenient fuel to produce and use. Natural gas is trapped in layers of rock frequently found with oil deposits. The United States still has untapped reserves of natural gas, but the methods of recovering it are expensive. Sometimes we must drill such deep wells to recover new natural gas that we use more energy than we produce.

In 1973 natural gas accounted for 31 percent of the United States' energy needs. Natural gas is used for heating buildings and water, industrial processing, and for cooking. Some scientists say that there will be no natural gas left by the year 2000 if we continue to use it at our present rate.

Coal

Coal is our nation's most abundant fossil fuel. It is used to generate electricity and in industries such as steel. Two methods of mining coal are used today: strip or surface mining and deep or underground mining. Current coal production is almost evenly divided between these two methods.

Surface mining, used when the coal lies close to the surface of the earth, is done by giant shovels that strip away the earth on top of the coal seam, and then scoop the coal from the earth—the land is "stripped" away. Most of the mining in the West is surface mining. But in the East, coal is mined by both surface and underground mining.

Underground mines are tunneled beneath the surface of the earth to reach the coal. Our oldest major deep mining area stretches along the Appalachian Mountains from Pennsylvania to Alabama.

There are great reserves of coal in the Western states. Western reserves have been developed slowly because of lack of industry and water in the areas near the coal and because of concern for the environment. The costs of land reclamation must now be considered in the overall cost of coal production.

Renewable Energy Sources

Geothermal Energy (Geo-Earth; Thermal-Hot)

The problem of disappearing fossil fuels is being tackled by imaginative people who want to use fuels which are "renewable"—fuels which cannot be "used up." Sources of energy such as water, wind, and the sun are renewable.

There are many places where the natural heat of the earth combines

with underground water to make steam. This steam is harnessed to run generators to produce electricity. (Geysers like Old Faithful in Yellowstone National Park are examples of steam power.)

Natural hot water can be used to heat buildings as is done in the entire city of Reykjavik, the capital of Iceland. Boreholes are drilled in the earth near hot springs. Water captured from these holes is pumped to storage tanks and pumping stations and then to the consumers.

Geothermal heat is clean and much less expensive to use than that from fossil fuels. However, the steam produced sometimes contains objectionable gases, and hot spring water sometimes contains more dissolved solid materials than are considered safe and manageable. Also, much of the earth's heat is buried so deep that it is not now useful. At the present time it does not pay to drill more than 10,000 feet to get the earth's heat. Scientists and engineers are working to overcome these problems. Most of the potential for geothermal energy in this country lies in California, Montana, and other Far Western and Gulf Coast states.

Solar Energy

The sun is our major source of energy. Its energy is used in many ways. The sun gives us energy as light, it is absorbed and used by plants to manufacture food, and it gives us heat, which we have just started to learn how to use. The energy provided by the sun is renewable and clean.

The most practical use of solar energy today is in direct conversion to heat. One method widely used consists of a flat surface to absorb the sun's heat. The heat is transferred to air or to a liquid, usually water, which is then circulated to a container where the heat is stored or used.

Within the next few years we may see the sun's energy used for heating and cooling buildings. Nearly one-fourth of the energy used in the United States is used for heating, cooling, and supplying hot water for buildings. Solar energy could greatly help in our effort to use less of our nonrenewable fuels.

Many experimental homes are already partially heated by different kinds of solar systems. These are being carefully studied to show how the design of new houses should be changed to make more efficient use of solar energy. Some schools have recently been equipped with experimental solar heating systems.

A second use of solar energy is the solar cell, which absorbs energy from the sun and converts it directly to electricity. This system provides most of the electricity used on unmanned space flights. This system is still much too expensive for home use. In the future, research and mass production may cut that cost enough to provide another new source of electricity.

Solar energy is also transformed by plants into stored chemical energy in a process called *photosynthesis*. Some scientists think that we can develop "solar plantations" with special plants grown to produce energy. We can get energy from plants by burning them or by changing them into other chemicals such as methanol to substitute for gasoline.

A Project To Do: A Solar Information Clearinghouse. Homes in almost every part of the country are already using solar energy. But many builders do not know how to get solar panels or design solar homes. Start a solar clearinghouse for the local library or technical school. Find all the articles you can on solar heating. Ask local architects to help. Include the location of nearby solar-heated homes in your clearinghouse. Tell local contractors about your project and ask them for any information they may have.

Wind

The source of wind power is the sun. Wind energy is a secondary form of solar energy. Man has harnessed wind to do his work for centuries. In our own American West, windmills pumped water, sawed wood, and generated electric power for half a century. From 1880 to 1930, over 6 million windmills generated electric power in the West. After that, cheap fuels were found to be better. Now that fuel is expensive, there will be more need for a modern kind of windmill.

Winds strong enough to use are found in the Great Plains and the Northeast States. We have seen that the Western pioneers made great use of the winds on the plains. The wind averages more than 12 miles per hour on the Western Plains and in the Northeast. It is strong and constant enough to be of real value. Practical wind-driven power-plants could probably generate nearly 20 percent of our electrical needs by the year 2000.

Someday, we may have large-scale wind generators to serve millions of people rather than just one house. They could give us clean, cheap power. However, scientists must learn more about wind behavior to find out how much power can be generated and the most efficient equipment to use. Much of the work and the experiments that have been done for the aircraft industry on the movement and effects of wind will help in developing wind power. Experimental wind power systems are planned to make enough electricity to serve about 100 homes, and later as many as 10,000.

Electricity

Electricity is a form of energy caused by the presence and motion of electrons, protons, and other charged particles.

Electricity can be seen in nature as lightning. It can be felt as a spark when you rub your feet along some carpeting and then touch another person or object. Commercially, electricity can now be created from all fossil fuels, water power, chemical reactions, nuclear fission, the wind, and the sun. More and more of our energy needs are being supplied by electricity.

Electricity is one of our most useful forms of energy. It can light, heat, and cool our homes, schools, and office buildings. It is the basis for radio, telephone, and TV. In addition, most of our labor-saving devices depend on electricity for power—clothes washers and dryers, dishwashers, water heaters; these and many more home appliances place heavy demands on our electrical supplies.

A Project To Do: Reading the Meter. Electric meters measure the amount of electricity used. The measurement is kilowatt-hours. (1 kilowatt = 1000 watts.) This is the amount of electricity needed to burn 10 100-watt light bulbs for 1 hour. (10 bulbs $\times$ 100 watts $\times$ 1 hour = 1000 watt-hours, or 1 kilowatt-hour.) Most electric meters have a set of dials which are read in multiples of 10. The dial on the far right indicates tens of kilowatt-hours; the next one, hundreds of kilowatt-hours; the next dial, thousands of kilowatt-hours, and so on. Reading the dials can be tricky because some of the dials read clockwise, others counterclockwise. When the pointer is between two numbers, take the lower number.

The illustrations on page 67 show different sets of meters. Can you read them? We've put the answers upside down, so you can check yourself.

Hydropower

One of the earliest forms of energy used by man was the energy of flowing water.

If you travel around the country, you can still see early water wheels which transformed the energy of flowing water into mechanical energy to grind wheat, run textile mills, and do many other forms of useful work.

Water power is an important source of electrical power. Huge dams were built on our largest rivers to harness this form of energy. Water from these dams goes through sets of propellers like fan blades, called turbines. Turbines make huge magnets whirl past coils of wire, creating electricity that is sent out for distribution to homes, factories, schools, and cities.

Nuclear Energy

All the material around you is a very concentrated form of energy. But we do not yet know how to easily change this "mass" into useful energy.

The only practical way scientists have yet found to change mass into energy is by "nuclear fission."

Nuclear fission takes place when the heart or core of a very big atom is broken into two or more parts. Even a very big atom is very small, smaller than anything a person can see even with the most powerful microscopes. The atom is the smallest part of matter than can still keep its chemical properties. It is composed of a center, the nucleus, surrounded by a swarm of electrical particles called electrons. If we can hit the correct atomic nucleus just right with another particle, called a neutron, we can make it explode, giving off energy, radiation, and a shower of other neutrons. If one of the new neutrons hits another nucleus, that too can explode, and we may set up a "chain reaction" of many exploding nuclei. This chain reaction is difficult to control; it is hard to keep the reaction going, and there are problems in getting just the right amount of energy we need.

Engineers have succeeded in designing nuclear powerplants to take advantage of the energy stored in the atom. Since 1 pound of nuclear fuel such as uranium, thorium, or plutonium can give off as much energy as

3 million pounds of coal, it is easy to see that nuclear power can be an important way to conserve fossil fuels.

Today, only about 1 percent of our energy comes from nuclear powerplants. But, over half the new electrical powerplants being built or planned are nuclear powered, so nuclear fission will become more important in the future.

There is another way to get energy from the atom which may someday prove to be a major source of energy. That is "nuclear fusion." Whereas "fission" is the breaking apart of heavy nuclei, "fusion" is the sticking together of very light nuclei, such as those of hydrogen or helium. Scientists still need to come up with a major breakthrough before nuclear fusion can be harnessed, but many laboratories around the world are working on nuclear fusion.

There are serious problems which must be overcome if nuclear power is to become an abundant source of electricity in the future. Nuclear power is relatively expensive. That is, the cost of building nuclear plants (capital costs) compared with coal- or oil-fired plants is considerably more. However, operating costs for nuclear plants are lower. Nuclear powerplants must be safeguarded from explosion, radiation leak, or theft of material which could be used for nuclear weapons. Our environment must be kept safe from the radioactive wastes generated by these plants, and from the heat ("thermal pollution") which could upset the balance of nature in nearby waters. All the safeguards that we rightfully demand for protection and reliability will add to the expense of nuclear power, just as they will insure that such energy converters are "good neighbors."

The Future

Solar, wind, geothermal, and nuclear energies are resources of the future. Today, no more than 3 percent of our nation's energy is supplied by these sources.

There are many other potential sources which also need more study and development. Currently the United States disposes of millions of tons of organic wastes, neither returning the valuable organic materials to the soil nor converting them to useful energy. Some of these waste materials could be converted to methanol to substitute for gasoline, to methane to increase our supply of natural gas, or burned directly as solids, like wood which was our principal source of power in the 1800's. Tidal power, fuel cells, ocean currents, ocean thermal differentials, free hydrogen, and osmotic pressures are other potential energy sources being examined as future supplies.

In spite of these potentials, for a long time yet, oil, natural gas, and coal will have to be our major supplies of energy, and these are in dangerously short supply.

A Brief Glossary

BTU/The British thermal unit, the amount of energy needed to raise the temperature of 1 pound of water by 1 degree Fahrenheit.

Calorie/The amount of heat needed to raise the temperature of 1 gram of water 1 degree Centigrade. About as much heat as is given off by burning one wooden kitchen match.

Chemical Energy/Energy stored in molecules, as in fossil fuels.

Crude Oil/Petroleum in its natural state.

Electricity/Energy derived from electrons in motion.

Electron/An elementary particle, with a negative charge, which circles the nucleus of an atom.

Energy/The capacity to perform work or produce motion.

Fossil Fuels/Fuels derived from the fossil remains of organic materials; includes petroleum, natural gas, coal, oil shale, and tar sands.

Generator/A machine for changing mechanical energy into electrical energy.

Geothermal Energy/Heat energy within the earth's outer crust.

Hydropower/Energy in stored or moving water.

Kinetic Energy/Energy possessed by objects in motion.

Motor/A machine that converts chemical or electric energy into mechanical energy.

Nuclear Energy/Energy within the nucleus of the atom. It can be released by nuclear fission or nuclear fusion.

Potential Energy/Energy that is stored in matter because of its position or because of the arrangements of its parts. Examples include the tension of a spring, water stored behind a dam, or chemical energy such as that contained in fuel.

Power/The rate at which energy is used or generated. Power is commonly measured in units such as horsepower or kilowatts.

Solar Energy/Energy radiated directly from the sun.

Turbine/A motor which is driven by the pressure of water, air, or steam against the curved vanes of a wheel to transform heat, chemical energy, or water pressure into mechanical energy.

Energy Measurements

Barrel (bbl)/1 barrel equals 42 gallons.

British Thermal Unit (BTU)/The energy required to increase the temperature of 1 pound of water by 1 degree Fahrenheit.

Watt/The amount of power available from an electric current of 1 ampere (amp) at a potential of 1 volt.

Kilowatt (kW)/1,000 watts. One kilowatt is the equivalent of about 1 1/3 horsepower.

Kilowatt-hour (kWh)/1,000 watt-hours. A unit of electrical energy equal to the energy delivered by the flow of 1 kilowatt of electrical power for

1 hour. (A 100-watt bulb burning for 10 hours will use 1 kilowatt-hour of energy, or enough to lift a 150 pound person 20,000 feet into the air.) One barrel of oil contains about 500 kWh of energy.

Megawatt (mW)/1 million watts, or 1,000 kilowatts.

Thousand Cubic Feet (Mcf)/1,000 cubic feet (of natural gas).

Therm/A unit of heat equal to 100,000 BTU's.

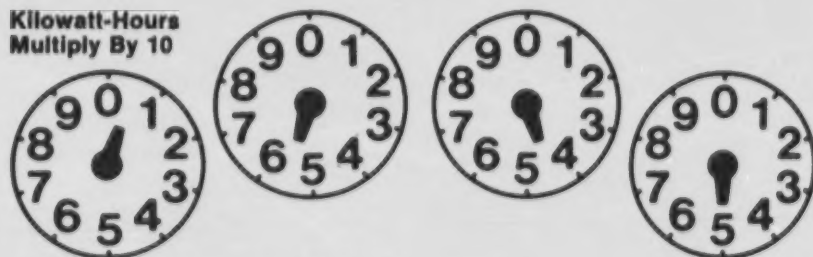
Kilowatt-hours
Multiply By 10



READING = kilowatt-hours.

Answer: 79,420 kilowatt-hours

Kilowatt-Hours
Multiply By 10



READING = kilowatt-hours.

Answer: 5,450 kilowatt-hours

Energy Units Translated into BTU's

1 kilowatt-hour	3,413 BTU's
1 ton of coal	25,000,000 BTU's
1 bbl crude oil	5,800,000 BTU's
1 gallon of gasoline	125,000 BTU's
1 gallon of No. 2 fuel oil	140,000 BTU's
1 cubic foot of natural gas	1,031 BTU's
1 Mcf natural gas	1,031,000 BTU's
1 therm of gas (or other fuel)	100,000 BTU's
1 cord of wood	20,000,000 BTU's

This unit contains five lessons in which students are asked to role-play citizens of a model community and to choose the energy source they consider best to heat and cool their homes and offices. It contains teaching suggestions, bibliography, film list, and data sheets on "Where Does the Energy We Use Come From?"

MINI-UNIT 3

Which Source of Energy Is Best for Heating My Community?

ENERGY-ENVIRONMENT MINI-UNIT GUIDE

ABSTRACT

A significant fraction (more than 60 percent) of our residential and commercial use of energy is devoted to the heating and cooling of homes and offices. This use of energy influences and is influenced by personal, local, and national policy decisions related to the wise or unwise use of our energy resources and our environment. In order to investigate the trade-offs that result from a particular energy-related decision, students are asked to pretend they are citizens of a model community and to choose the energy source they consider the best to heat and cool their homes and offices. Students research each source (fossil fuels, solar, geothermal, etc.) and compare in a mock community meeting their cost, availability, environmental effects, and other characteristics. Students are given opportunities to use their critical thinking skills in doing research and evaluating sources, and also to engage in group decision-making processes.

Recommended level:

Social studies and general science classes grades 5-8.

Time required:

Five to eight 45-minute class periods, depending on student research time allocated.

Major teaching strategies:

Classroom discussion, individual and group research, simulation of community meeting, student charting, notetaking, and reporting.

Advance preparation:

- Collect cartoons, headlines, newspaper articles, brochures on energy-environment problems and on the seven sources of energy (coal, electricity, geothermal, natural gas, nuclear, oil, and solar) examined in this mini-unit, and prepare a bulletin board using these materials. (See bibliography for a list of available materials.)
- Duplicate enough copies of each of the seven Data Sheets on energy sources so each student in the corresponding research group has a copy.

Key Ideas

1. We presently use, either directly or indirectly, seven sources of energy to heat and cool our homes: oil, natural gas, coal, electricity, nuclear, solar, and geothermal.
2. Sources of energy for heating and cooling homes differ in their availability, their costs, and their environmental effects.
3. Energy-environment decisions require making value judgments of the trade-offs involved; a decision involves the acceptance of the possible disadvantages of the choice along with its advantages.

Objectives

At the completion of this activity the student should be able to:

1. Name several energy sources we use to heat and cool our homes and offices.
2. Identify several factors that might influence the choice of an energy source for heating and cooling our homes and offices.
3. Choose and justify his/her individual choice of energy source for heating and cooling homes in his/her community.
4. Research and report to the group information that might influence a group decision (e.g., information on the availability and cost of natural gas for heating homes).
5. List several components of a group's decision-making process.

Teaching Suggestions

LESSON 1—Students as Citizens of a Model Community

In order to set the stage for energy-related decision-making, present students with the opportunity to determine, through their roles as citizens of a totally new community, how they might change their community if they could start anew. Lead them to discuss whether some of our energy-environment problems might be solved by new community designs. In

particular, have students begin examining possible sources of energy for heating and cooling homes and offices of their new community.

1. Have students identify what they consider the most important problems in their community.

- Begin lesson by having students brainstorm about what they consider to be problems in their community. For example, is there inadequate housing or inadequate park and recreation facilities, poor siting of factories and highways, too much pollution, too much crime, not enough theaters?

Alternatively, they might be asked to collect, for several days prior to this lesson, articles and news displays concerned with what they consider to be problems in their community.

- Have students share their opinions about which problems they believe are the most serious. Poll their opinions and list on the blackboard the problems in order of their seriousness to the class.

2. Present students with the hypothetical situation of being members of a new model community.

"Suppose that everyone in our class could be citizens of a future, totally new community. In what ways would you want this new community to differ from our present community? Which of our community problems could we solve if we built our new community differently? Which might still occur?"

"What should we name our community?" (Students may want more time to think about this and decide later.)

3. Relate discussion of new community to energy use and to home heating.

"We have been collecting for several days articles and news clippings on various energy-environment problems. Would we be able to solve some of these problems if we built our new community differently?"

"For example, one of the opportunities we would have in completely designing or redesigning our new community is to decide what kinds of houses we want and which source of energy would be best for heating and cooling our homes and offices. If we choose the 'right' source, could we eliminate some of our energy shortage problems or environmental problems due to energy production and use?"

4. Initially examine the sources of energy which are available for heating and cooling homes and offices.

"Let's suppose that we are all home owners in our new community. As home owners we must decide which source we want to use to heat and cool our homes and offices. For now we will pretend that all of the sources of energy are available to use and that all of us will use the same one. What sources of energy are available to heat and cool homes? What sources of energy are now used to heat your home or apartment?" (List responses.)

Students at this point may not be aware of all of the energy sources that are available and may not know the advantages and disadvantages of each. The bulletin board should provide some ideas for discussion. After student ideas have been listed, refer to the bulletin board. Ask students to go to the board and select any article they wish. Then ask them to skim the article, cartoon, etc. and answer the following:

- a. Which source of energy is described in your article? (electric, oil, coal, geothermal, etc.)
- b. Would you prefer this source for our community?
- c. What are your reasons for preferring or not preferring this source as opposed to others?

These questions may be written on the board for easy referral. Allow 10-15 minutes for students to read and summarize their reactions to the materials. (This may be continued into the next period.)

Continue the lesson by having the students share their reactions.

List each different type of energy on the board as it is discussed. (Keep the summaries brief—one to two minutes per topic, for instance.) The students will end with a fairly complete summary of the source of energy available.

5. End lesson by asking each student as an assignment to identify his/her personal preferences for home heating energy sources.

Ask each student to rank his/her first, second, and third choice of home energy sources from the list on the board.

"My choices for a source of energy for my community are":

1st _____

2nd _____

3rd _____

Have students keep this list for future reference.

LESSON 2—Factors for Judging Energy Sources

Through classroom discussion, several factors which might be important in making a choice among energy sources should be identified. These help guide the students' research. Form the research groups and begin the research.

Advance preparation: Assemble as many textbooks and references on energy and its sources as possible or have a group of students do this. Make student copies of Data Sheets which are provided in this unit. Four or five copies of each Sheet should be sufficient for average-size class—30-35 students.

1. Review energy sources identified in previous lesson.

Introduce the lesson by asking students to review the sources of energy that are available to a community. Sample lead-in questions might be:

"Yesterday we started to explore some of the sources of energy which are available to a community. Which sources did we identify?" (List these.)
"Does anyone know any other sources of energy?" (Students may suggest tidal, wind, organic waste, etc. These are presently used only in isolated circumstances.)

2. Have students identify their needs for further information about energy sources. Have each student list the sources he/she needs to know more about:

"The sources of energy that I would need to know more about are: _____, _____, and _____."

3. Have students choose topics and form research groups.

Using the list of energy sources, allow students to choose an energy source for investigation. Try to establish groups for all seven energy sources discussed in the Data Sheets: solar, coal, oil, natural gas, geothermal, electricity, and nuclear.

4. Develop with the class the important factors on which to compare the sources of energy used for home heating and cooling. Begin discussion with:

"What would we need to know about a source of energy so that we could judge whether or not it would be good for our community?"

Depending upon student responses, several of the following questions might additionally be asked to promote discussion:

- "How does it heat and cool a home?"
- "What does it cost to install the equipment, etc. for home heating and cooling?"
- "How much does it cost to heat and cool a home per month or per year by this method?"
- "How much of this energy source is available?"
- "Are there any problems with using this source of energy?"
- "How does it affect people? The environment?"

Have students decide on four or five criteria to guide their research.

5. Introduce available reference resources. Include Data Sheets.

Have students mention and/or review the references available to them (textbooks, almanac, atlas, encyclopedias, etc.). Introduce and distribute Data Sheets to the appropriate groups.

"One resource that we have about sources of energy are these Data Sheets. There is one for each: solar, geothermal, coal, oil, natural gas, nuclear, and electricity. They will help you answer some of the questions that we have

listed to guide our research. Use these as you would other written references."

A Data Sheet is a brief summary of current factual information related to a specific form of energy.

Have resources available in a central location.

6. Have resources groups meet and begin research.

Use the remaining time for small group meetings and student research. Teacher can circulate among the groups and act as a resource. Ask each group to assess its progress at the end of the research time and determine its needs.

7. (Optional) Encourage use of non-text references in research.

a. Invite representatives of oil, gas, coal, and electric industries in your community to visit and talk with the class and give specific information to the corresponding research group.

b. Have class or individual research group visit a local mine, refinery, generating or processing plant of a particular energy industry.

c. Invite parents to visit the class to describe how their homes or apartments are heated or cooled.

d. Invite plumbers or heating contractors to the class to describe home and office heating systems and installation costs.

LESSON 3—Investigating Energy Sources

Groups suggest ways of sharing their new learnings with other members of the class and continue to research their topics. Additional research periods might be inserted here if necessary or if desired for optional activities.

1. Have the class suggest ways that they could summarize their new learnings for other members of the class.

Class can brainstorm in ways of sharing information so that one source of energy can be chosen for their new community. Sample lead-in question might be:

"We have listed the kinds of information that we want to obtain for each source of energy. How can we share our information so that we as a class can decide on the source we prefer for our community?"

List ideas. Possible suggestions include: preparing outlines, making a summary chart, writing a report, preparing posters, drawings, and other graphics, etc.

The class may agree on one form for all groups—a summary chart, for instance—or each group may choose its own method. (Note: only the summary chart will be explained in this mini-unit.)

Help students acquire any special materials needed for the method they have chosen—poster paper, Magic Markers, etc.

2. Have groups meet and continue research.

Use the remainder of the time for group meetings and research. Teacher may circulate among the groups and assess progress and special needs. Individual students needing help may be paired with more capable students or may be grouped with other students and work with the teacher on reading and interpreting information.

At the end of the lesson ask each group to assess its progress and set a group goal for the next lesson.

3. (Optional) Have students investigate how decisions are made in the local community. Are public hearings held to obtain citizen input? Is there a City Council or Legislature? Is there a Public Service Commission or Zoning Board which regulates siting of generating plants, refineries, and location of transmission lines?

LESSON 4—Planning a Community Meeting

Groups finish research and the class plans the agenda for the community meeting.

1. Have the class set the agenda for the community meeting.

Ask students to decide on an agenda for the community meeting. Sample agenda might be:

- a. Call meeting to order
- b. Set purpose of meeting (to decide on one source of energy to use for heating and cooling homes)
- c. Group reports (list order)
- d. Discussion (note advantages and disadvantages of each energy source)
- e. Voting (use hand vote or secret ballot)
- f. Evaluation of decision (what is important to us?)

Have group decide if a Chairperson and Secretary will be needed. If so, allow them time to think about their choices and to be prepared to vote on this at the end of the lesson.

2. Have groups complete research and prepare any necessary materials for their summary report.

Remind the class that this will be their final work period. Circulate among the groups checking progress and needs. Help students prepare charts, posters, outlines, etc. as needed. Ask each group to give a brief progress report and to plan their presentation for the meeting.

3. (Optional) Have class select Chairperson and Secretary for the community meeting.

End the lesson by allowing students to nominate and vote for Chairperson and Secretary for the community meeting. Groups may also determine the

order of group reports by drawing numbers, using alphabetical order, volunteering, etc.

LESSON 5—Which Is Best For My Community?

Students conduct a community (class) meeting in order to practice group decision-making skills. They also evaluate the decision made.

Advance preparation: Make copies of attached Energy Summary Chart for distribution to entire class. Arrange desks in a circle to facilitate discussion. Meet with Chairperson and Secretary and review the agenda and use of the summary chart.

1. Begin meeting by establishing the procedures.

Have Chairperson call meeting to order and post a chart listing the agenda for the meeting. Be sure to include the order of group presentations. Have the Secretary pass out the Energy Summary Chart (change to headings conforming with group's criteria) and briefly explain how it can be used for note taking. For example, the students may jot figures, examples, notes, pluses (+) or minuses (-), etc. in the appropriate columns. They should record whatever they feel will help them compare the advantages and disadvantages of the sources of energy and be prepared to make a decision on the source of their choice.

2. Have groups give reports.

Set a time limit for each, such as three minutes. Allow a brief question period at the end of each presentation.

3. Review and discuss reports. After the last committee report, allow the students to review their notes and have a brief general discussion of the energy sources. Encourage discussion of advantages and disadvantages of each energy source. Group may wish to identify which is best in terms of other uses, costs, lifespan, environmental effects, etc. Allow time for each person to think about his decision.

4. Allow students to vote on their preferred source.

Students may use hand vote or secret ballot for voting. Students will select their preferred source of energy for heating and cooling homes.

5. Guide evaluation of the decision.

Announce the results. The group may want to rank its second and third choice also. Briefly discuss the decision made. Ask:

"What influenced your decision most?" (Listen to several responses.)

"What are the advantages and disadvantages of the source of energy chosen?" (Have students refer to notes on summary chart.)

"What does this decision indicate about the factors that are important to us as a group? (Is cost important? Availability? Environmental effects?) What were we willing to trade off?"

"Why can't a real community decide as we have? What problems does it face that we have not considered?"

(Possible considerations:

- All sources of energy are not equally available to all communities.
- Homes and businesses already have some source of heat and cooling which would have to be converted if a change was made. This change would be costly.
- Some sources of energy need improved technology before they can be useful for large communities.)

Have students compare their original choice (on the first day) with their individual final choice and the group's choice. Did their choice change as a result of new information?

6. Have students review the process they have used in making this decision. Focus attention on the decision-making process that has been used in this mini-unit. Ask such questions as:

- a. What was the problem that we wished to resolve in this unit? (Define the problem.)
- b. What method did we use to solve the problem? (Divided into groups, did research, gathered information, established factual base for decision making.) Why did we divide into seven groups? (We identified seven alternative choices.)
- c. How did the group reach its decision? (Held meeting, shared information, summarized, discussed, voted.)
- d. How did we evaluate our decision? (Reviewed advantages and disadvantages of chosen source, inferred our priorities from such a choice, related choice to practical limitations which exist in real communities.)

After this review, students may want to record the steps of the decision-making process:

1. *Define* the problem.
2. *Plan* a method for investigating the problem. Identify alternative choices.
3. *Gather* and evaluate information.
4. *Decide* and act.
5. *Evaluate* the decision made.
7. (Optional) Have students compare their choice for their new model community with the sources used in their present community. What are the trade-offs in their present community?

ENERGY SOURCE SUMMARY CHART

Energy Source	Factor	Availability		Cost	Environmental Effects		
		Now	Later				
1. Oil							
2. Natural Gas							
3. Coal							
4. Electricity							
5. Nuclear							
6. Solar							
7. Geothermal							

DATA SHEET

Where Does the Energy We Use Come From?

Where Does the Energy We Use Come From?

Primary Energy Sources

There are five *primary* sources of energy that are naturally available to us on earth: solar, chemical, nuclear, geothermal, and tidal energy. Two of these, the chemical energy of fossil fuels and nuclear energy are *stored* or *potential* forms of energy. The other three—solar, geothermal, and tidal energy—are *kinetic* forms of energy; that is forms which are active and always in motion. While we can use the energy in the stored sources of energy whenever we choose, we can use the kinetic forms only when nature makes them available to us; for example, sunlight is only available during daylight hours. In the sections that follow we will briefly discuss each of the primary sources.

Solar energy: Solar energy is a kinetic form of energy. It is more precisely called radiant energy, much of which is observable as visible light. A major portion of the sunlight which approaches earth is reflected by the atmosphere back into space. Although only roughly half of the solar energy reaches the ground, half is still a tremendous amount. If all the solar energy reaching the ground could be stored for 48 minutes. It could provide as much energy as used worldwide in 1970.

A very small part (1/5000) of this energy interacts with plants and fuels the photosynthesis process. Solar energy, thus, is indirectly the source of the food energy on which we depend. It is also the source of the chemical energy which was stored hundreds of millions of years ago in the plant life of the swampy jungles of earth. We are using stored solar energy when we burn the fossil fuels: coal, oil, and natural gas.

The sun's radiant energy also heats the land and the oceans and thus provides the energy for the great air and ocean currents—the winds and waves. Historically, wind and water currents were early sources of energy and were harnessed by windmills, sailboats, and waterwheels. With increases in the world's population and the rise of cities, however, these sources became inadequate. Today we get some of our energy from these wind and water currents in a different manner. Some of the sun's energy evaporates water from lakes and oceans. The water rises and is carried in the winds. If the water falls on the mountains, we get some of the energy for our use by letting the mountain-fed streams and rivers turn the turbines of hydroelectric plants to produce electricity.

Most of the solar energy reaching the ground is unused by man. It is available during the daylight hours throughout the world in varying amounts. However, since it is a kinetic form of energy, it must be used immediately or it must be converted into some potential form of energy for later use. Presently, sunlight is being used as the sole source of heat for a few homes. However, collection and storage of solar energy for later transportation and use is still difficult. In particular, we have not perfected practical and economical methods of collecting solar energy and converting it into electricity. Since the lifetime of the sun is many billions of years, for

all practical purposes this energy source will always be with us. It is a *continuous* source of energy which does not need to be renewed.

Fossil fuels: The most important form of stored energy is the chemical potential energy of the fossil fuels: coal, oil, and natural gas. As we have said, this energy was originally solar energy hundreds of millions of years ago. Coal began to be formed when the huge mosses and ferns of the Paleozoic swamps died and fell into the mud. They were acted on by anaerobic bacteria (bacteria which don't need oxygen) and then by pressure and heat as they were buried under tons of sediment and converted to the almost pure carbon of coal. When the carbon atom is burned (oxidized), it releases this stored energy.

Petroleum and natural gas were formed in a similar manner. Some of the plant and animal like sank to the bottom of the great sea beds and went through a different chemical transformation under pressure and heat to form the "hydrocarbons," the complicated molecules of hydrogen and carbon characteristic of petroleum. Their stored energy is also released by burning.

Fossil fuels are used extensively because they are relatively easy to find, collect, store, and transport. Coal, oil, and natural gas resources can be located through geological surveys. Once discovered, the fuels can be removed from the ground by mining or drilling and transported by pipes, truck, rail, etc. to any destination. Although the formation of fossil fuels is continuing, the process is very slow. It would take another 300 million years or so to produce an amount equal to that which has been built up so far. Since our energy use is much more rapid than this, we are likely to use up all of our fossil fuels. For this reason, fossil fuels are called *non-renewable sources of energy*.

Nuclear energy: A form of potential energy which is of growing importance is that stored in nuclei, the tiny, dense cores of atoms. Nuclei are made up of the elementary particles—protons and neutrons. It is by rearranging these particles that nuclear energy is stored and released. There are two important examples of this: the fission reaction and the fusion reaction. In the fission reaction, the heavy nucleus, or center, of an atom such as uranium is split into two lighter ones. In this process, mass is converted into energy and it is this energy we obtain from the hot interior of a nuclear reactor.

The fusion reaction involves very light nuclei. It is the same reaction which is the source of the sun's energy. In a typical example, four hydrogen nuclei, by a complicated series of reactions, combine to form the heavier helium nucleus (two protons and two neutrons). Again, some of the mass has been converted to energy.

Nuclear energy becomes available to us in the nuclear reactor of an electric power plant. The energy of the nuclear reaction heats water, for example, and converts it to steam. This turns a turbine which produces electricity much as a river is used in a hydroelectric power plant. The electricity is then transmitted to our homes through wires. The major fuel for

the fission reaction in nuclear reactors is Uranium 235; it is available in limited quantities throughout the world.

Like the fossil fuels, the nuclear fuels are also presently *non-renewable*. However, if all of the many technical and safety problems of a new type of reactor called the breeder reactor can be overcome, nuclear fuels will be much more plentiful. The breeder reactor, while it uses up some nuclear fuel to produce electricity, produces a by-product which can be reused as a nuclear fuel to produce more electricity.

Geothermal energy: The earth's interior is molten rock, or "magma" as the geologists call it. There is a tremendous amount of energy in the earth. Although heat energy is an active or kinetic form of energy, the heat of the earth is effectively stored and insulated by the solid, thin crust on which we live.

We are not sure how the energy got there. It may have been stored in the molten blob of original earth, or it may have come from the impact of countless chunks of matter pulled to it by the earth's gravity. We are fairly certain that the radioactivity of some of the material in the earth keeps it hot. There seems to be enough uranium, radium, and other naturally radioactive material in the earth's interior to produce that relatively small amount of heat needed to make up for that lost through the surface. In this sense, geothermal energy does not need to be renewed and is essentially a *continuous* source.

The geological conditions which produce geothermal energy restrict this energy source to a few geographic areas. Where available, it is inexpensive, clean, and has few adverse environmental effects. It is available to us in those regions where the magma is close to the surface and the energy can leak out from the core through cracks in the crust. Volcanoes, geysers, and hot springs are visible evidence of geothermal reservoirs, but more sophisticated techniques will soon allow us to find others not evident on the earth's surface. If available as hot water or steam, geothermal energy can be used to heat buildings. Some 500 homes and offices in Klamath Falls, Oregon, are heated by hot water drawn from a hot spring running under the town. The only large-scale use of it is in The Geysers in California where dry steam—steam so hot there are no water droplets in it—is piped to steam turbines and used to generate electricity.

Tidal energy: The last of the big five, tidal energy, is probably of least importance for our use. The source of this energy is the kinetic energy stored in the rotation of the earth-moon system. Like geothermal energy, it is another example of the successful temporary storage of energy in the kinetic form. It is *continuous* and does not need to be renewed. This energy is converted to motion of the oceans through the gravitational attraction of the moon on the oceans' contents. Ocean water is pulled toward the moon on the near side (and bulges in the other direction on the far side). To use this tidal energy, the up and down (in and out) motion of the water must be used to turn a turbine and produce electricity. This electricity can then be carried by wires to homes and offices.

Tidal generation of electricity is only practical where geologic peculiarities cause high tides. The first tidal dam and generator were built in the Rance estuary on France's Brittany coast where tides rise and fall an average of 26 feet.

There has also been some interest in building a tidal conversion facility at Passamaquoddy Bay on the far northern coast of Maine, but it does not yet appear commercially usable. We do not expect much contribution to our total supply of energy from this form.

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Our Minerals and Energy Resources, filmstrip, 1970. \$10.00. Coronet Films, Division of Esquire, Inc., 65E South Water Street, Chicago, Illinois 60601.

The World of Energy, filmstrip. National Geographic Society, Department 1037, Washington, D.C. 20036.

Note: Additional references to books, articles, and films are provided in the *NSTA Energy-Environment Materials Guide*.

Materials List

- Duplicate Data Sheets for class: "Where Does the Energy We Use Come From? Primary Energy Sources."
- Fan, turntable, or other electric appliance that moves
- Incandescent bulb and socket
- Candle or alcohol lamp
- Radiometer (available from, for example, Welch Scientific Company, #1733, \$6.75)
- Obtain books, articles or non-text materials on primary energy sources. (See Bibliography.)

This unit contains four lessons designed to help students develop criteria for determining when energy is being used and identifying and investigating energy sources. It contains teaching suggestions, bibliography, film list, and excellent resource data sheets on natural gas, oil, coal, electricity, nuclear energy, solar energy, and geothermal energy.

MINI-UNIT 4

Energy and Its Natural Sources

ENERGY-ENVIRONMENT MINI-UNIT GUIDE

ABSTRACT

What is energy? How do we know we are using energy? What are the sources of energy naturally available to us? These questions are investigated in this mini-unit, which might serve as a first introduction to other discussions related to energy. Students develop criteria for identifying when energy is being used, and identify energy sources. The five primary sources of energy (solar, fossil fuel, nuclear, geothermal, and tidal) are investigated. Students increase their awareness of the origin of our energy dilemma by associating the most frequently used primary sources with their non-renewability.

Recommended level:

Science and social studies classes, grades 6-8, depending on reading and vocabulary skills.

Key Ideas

1. When energy is being used we observe or sense heat, light*, or motion; an energy source is a source of heat, light, or motion.
2. There are five primary energy sources naturally available for use on earth: fossil fuels, nuclear fuels, solar energy, tidal energy, and geothermal energy.

*Includes non-visible radiant energy, such as x-rays.

3. Fossil fuels and nuclear fuels are stored, or potential, forms of energy and are non-renewable. Solar, tidal, and geothermal are kinetic forms of energy. They are also continuous sources of energy which do not need to be renewed.

4. Almost all of our present energy use is derived from the non-renewable, stored primary sources that are easily transported; the large-scale use of the continuous sources is limited by present technology.

Objectives

At the completion of this activity the student should be able to:

1. *Distinguish* activities or items that use energy from those that don't.
2. *Identify* the immediate source of energy in an activity where energy is being used.
3. *Identify*, in an activity where energy is being used, the primary source of energy.
4. *Distinguish* the most-used primary sources from the least-used, and the non-renewable from the continuous sources.
5. *Describe* one or more of the problems that might result from increased use of fossil fuels.

Teaching Suggestions

LESSON 1—Energy in Use

Students are led to develop a criterion for identifying when energy is being used (see Key Idea #1, this section) by classifying their observations from several activities.

1. Perform several activities that involve the production of light, heat, and/or motion.

- Begin class by doing a few physical exercises with students (e.g., side-bends, toe-touching, running-in-place, etc.). While exercising, ask students: "What is happening as we exercise?" (Possible responses: getting tired, moving parts of our bodies, getting warmer.)

Record responses on blackboard or overhead projector transparency in table similar in format to the following:

<i>Activity</i>	<i>Observations</i>
people exercising	(moving, getting warmer)

Responses to note involve ideas of *moving* and *getting warmer*.

- Turn on record player, fan, or other electric device that moves. Ask students:

"What happens when I turn the fan switch on?" or "How can we describe to someone that the fan is ON?" (Fan blades *rotate* or *move*.)

Add "fan ON" under *Activity* and "blades moving" under *Observations* to table written on blackboard.

- Next, turn on incandescent light bulb. Ask students:

"What do we observe when we turn on the light bulb?" (See light, feel warmth or heat.)

Add "light bulb ON" under *Activity* and "light, heat" under *Observations*.

- Light a candle or alcohol burner. Ask:

"What do you observe when the candle (or alcohol burner) is lit?" (Light and heat.)

Add "candle burning" under *Activity* and "light, heat" under *Observations*.

Place radiometer (see materials list) on a table. When the vanes are moving very slowly, bring a flame (alcohol or candle) close to the radiometer or place it in the sun. Ask:

"What happens when we bring the candle close to the radiometer (or place it in the sun)?"

Similarly, on table:

<i>Activity</i>	<i>Observations</i>
people exercising	(moving, getting warmer)
fan ON	(blades moving)
light bulb ON	(light, heat)
candle burning	(light, heat)
radiometer near candle	(motion)

2. Summarize activities and develop criterion for energy in use.

Ask students if they are familiar with the word *energy*. How can they determine when energy is being used? Was energy being used in any of the listed activities?

Introduce the concept of energy-in-use by informing students that in each of the activities they performed or observed, *energy* was being used. Ask students:

"If we performed other activities, how would we know that energy was being used?"

To answer this question review the table of activities and observations with students and ask:

"What observations do most of these activities have in common?" (moving, getting warmer, light)

Have students summarize observations by completing a chart similar to the following:

Activity	How Do I Know Energy Was Being Used?	(Leave room here for two more columns to be used later)
people exercising	(motion, getting warmer)	
fan ON	(motion)	
light bulb ON	(light, warmth)	
candle burning	(light, warmth)	
radiometer near candle	(motion)	

Ask students:

"How do we know that in each of the following activities energy is being used?" (Acceptable responses in parentheses.)

car running at 30 mph	(moving)
hamburger cooking on charcoal grill	(getting warm)
clothes being washed in washing machine	(moving)

Have students add these activities and responses to their charts.

3. End lesson by formulating description of energy in use. Ask students to complete the following sentence after completing their charts:

"I know energy is being used in an activity if I observe _____. (heat, light, or motion)

4. (Optional)

a. Activity 1 in Lesson 2 might be used as a conclusion to Lesson 1 or as a home assignment, depending on time constraints and student abilities at independent work.

b. Students may wish to summarize their new learnings by developing a bulletin board entitled: "Energy in Use—Heat, Light, and Motion." Have them collect pictures that show some activity where heat, light, or motion is produced.

LESSON 2—Energy Sources

Students identify several sources of energy and the general characteristics of a source of energy.

1. Review and apply criteria for energy in use.

- Ask students to share their reactions to the incomplete sentence:

"I know energy is being used in an activity if I observe _____."

List key criteria on the board. (Possible responses include: heat, warmth, motion, light, etc.)

- After a brief discussion, divide the class into three groups and assign the topic of Heat, Light, or Motion to each group. Allow 10 minutes for students to brainstorm and list as many energy users as possible under each topic.

- Make a summary chart of responses:

Energy is being used because I observe:

<i>Light</i>	<i>Motion</i>	<i>Heat</i>
sun	car	home furnace
lamp	elevator	sun
	electric mixer	electric heater
	windmill	person running

Note items that appear under more than one heading. Point out that there are many cases where we know that energy is being used to produce not only heat, or light, or motion, but heat *and* light, or heat *and* motion, or light *and* motion, etc.

2. Identify the immediate source of energy for each activity listed.

- Refer to the list of activities in which energy was being used and select one; for example, the light bulb, and ask:

"Where do we get the energy that enables the light bulb to produce light and heat?" (Electricity from wall or ceiling outlet.)

- Summarize the responses by adding a third column to the table from the first lesson:

<i>Activity</i>	<i>How Do I Know Energy Was Being Used?</i>	<i>Immediate Energy Source</i>
people exercising	motion, warmth	(food)
fan ON	motion	(electricity)
light bulb ON	light, warmth	(electricity)
candle burning	light, warmth	(candle wax)
radiometer near candle	motion	(heat of candle flame or sun)
car running at 30 mph	motion	(gasoline)
hamburger cooking on charcoal grill	getting warm	(charcoal)
clothes being washed in washing machine	motion	(electricity)

• Complete with students the third-column entries of several activities until the concept of an immediate energy source appears understood.

3. Conclude lesson by having students identify the general characteristics of a source of energy.

After several examples, ask students to identify the general characteristics of a *source* of energy. (A source of energy is something capable of producing light, heat, or motion.)

Students may be assigned to complete table and also identify the source of energy for each energy use activity listed in (1) above.

LESSON 3—Primary Energy Sources

Students obtain information on the five primary sources of energy—solar, geothermal, chemical, tidal, and nuclear through reading and discussion. They identify the primary sources of energy for their examples of energy in use.

1. Review the general characteristics of a source of energy.

(A source of energy is something capable of producing light, heat, or motion.) Elicit one or more examples of a source of light, heat, or motion.

2. Introduce students to the five primary energy sources by having them read the Data Sheet, *Where Does the Energy We Use Come From? Primary Energy Sources*.

• Ask students:

"What are our basic or primary sources of heat, light, or motion?"

List ideas. Continue by adding:

"Today we will read the handout *Where Does the Energy We Use Come From? Primary Energy Sources* to answer the following:

What are the primary energy sources that are naturally available to us? Which sources of energy are *continuous* and which are *non-renewable*?"

These are likely to be new vocabulary words. Have students research their meaning in dictionaries and discuss the difference between renewable and non-renewable, and the difference between continuous and non-continuous. (There may be some confusion since the primary sources are not divided into non-renewable and renewable, and continuous and non-continuous. The sun, for example, is considered a continuous source, but it is not a renewable source like the supply of wood.)

- Distribute copies of handout and write purpose for reading on the board. Allow 10-15 minutes for reading. You may want to circulate among students or form a small group of students who would need teacher guidance to read material with understanding.

Students might also be assigned other reading materials (see bibliography) or be shown films or slides relating to primary energy sources.

3. Discuss the handout and other materials. Review and discuss general purposes for reading.

Other follow-up questions might include:

a. "What is the difference between *potential* and *kinetic* energy? Which of the five primary sources are *potential*? Which are *kinetic*?" (These concepts might be further emphasized if presented in context of a science class.)

b. "Name some of the indirect forms of solar energy." (Food, coal, oil, natural gas, winds, watercycle.) "Why aren't we using direct solar energy to supply us with the energy we need?"

c. "What do coal, oil, and natural gas have in common?" (All are fossil fuels, formed millions of years ago, are types of chemical energy, must be burned to release energy, are easily stored and transported, can be totally consumed, etc.)

d. "Explain a fission reaction." (A heavy nucleus is split into two lighter ones.) "Explain a fusion reaction." (Two or more light nuclei fuse, or come together, to make one heavier nucleus.) "What is necessary to make nuclear energy nearly a renewable source?" (The breeder reactor.)

e. "Why can't geothermal energy be used to a greater degree?" (The geysers and hot springs that produce it are restricted to certain geographical areas.)

f. "What conditions are necessary for the use of tidal energy?" (There must be high tides so that the rise and fall of the tide can generate electricity.)

g. "Rank the natural sources of energy in terms of importance to our life." (This is meant to be students' personal reactions.)

4. Associate the examples of energy in use with the five primary sources. Have students refer to their charts on energy in use and add another heading entitled *Primary Energy Source*. Select one or more examples from the *Activity* list and identify the primary source. For example, for people exercising, ask:

"If food is the source of energy for people, which of the primary sources of energy contributes to food? (Solar energy.)

Ask students to complete the list and be prepared to discuss the results tomorrow. Completed chart would resemble the example below:

<i>Activity</i>	<i>How Do I Know Energy Was Being Used</i>	<i>Immediate Energy Source</i>	<i>Primary Energy Source</i>
people exercising	motion, warmth	food	(solar energy)
fan ON	motion	electricity	(fossil fuel)
light bulb ON	light, warmth	electricity	(fossil fuel)
candle burning	light, warmth	candle wax	(fossil fuel)
radiometer near candle	motion	candle or sun	(fossil fuel or solar energy)
car at 30 mph	motion	gasoline	(fossil fuel)
hamburger cooking on grill	getting warm	charcoal	(solar)
clothes being washed in washing machine	motion	electricity	(fossil fuel)
(Other)			

LESSON 4—Conflicts Between Energy Use and Limited Sources

The most-used energy sources are re-examined to determine why they are the most-used. Students are made aware of the origin of our energy dilemma: our most-used sources are non-renewable sources.

1. Determine which primary sources are used the most.

- Review with students information from previous lesson associating an activity where energy is being used and the primary source of that energy. Ask students:

"Are there some primary sources that seem to be used more than others? Which primary sources appear not to be used for any activity in which energy is being used?" (Tidal energy, geothermal energy, and solar energy may be identified; however, all plants in the food chain utilize sunlight and hydroelectric power has its origins in the radiant energy from the sun;

nuclear energy sources are being used in some areas to generate electricity.)

"Do you know what percentage of the energy we use in this country is derived from the fossil fuels? What percentage from the nuclear fuels?"

- Display or distribute copies of Transparency 1. Discuss with students:

"Which sources shown are called fossil fuels?" (Coal, oil, natural gas.)

"From which primary source do we get most of our energy?" (Oil.)

"Which primary sources are not included on the graph? Why?" (Geothermal and tidal contribute much less than 1 percent to the total use.)

"What percentage of our energy is obtained from solar energy?" (4 percent.) "How?" (Energy is from hydroelectric sources—solar energy turns water precipitation-evaporation cycle.)

"What percentage of our energy is obtained from fossil fuels?" (95 percent.)

Ask students to make a list of the primary energy sources listing the most frequently used first, the next most frequently used second, etc.:

Fossil Fuels	95%
Solar Energy (hydroelectric)	4%
Nuclear Energy	1%
Geothermal Energy	less than 1%
Tidal Energy	0%

(Note: No detailed information is provided students on the last two entries, so these items may be reversed by them. The correct order, however, is that above (since no tidal energy sources are presently being used in the United States).

2. Investigate with students reasons why some sources are used more than others.

Ask students why they think fossil fuels, particularly oil and gas, are used more than the other sources. Through discussion bring out such factors as:

- Availability within different areas of the United States or the world
- Ease of storing
- Ease of transporting
- Ease of extraction

All of which might determine cost.

Information concerning these factors is presented in the student reading sheets.

You might suggest that students construct ordered lists of the primary sources on each of these factors or answer questions such as:

"Which source is most easily stored? Why?"

"Which source is most easily transported? Why?"

3. Relate most used primary sources to non-renewable sources.

Refer students back to ordered list of most frequently used sources. Ask students:

"Which sources are non-renewable, that is, which sources are being used up faster than they are being made?" (Fossil fuels, nuclear fuels.)

"Which sources are continuous sources, sources which do not need to be renewed?" (Solar, tidal, geothermal.)

If these have been answered correctly, ask:

"Do you see any problems that might arise because the sources that are used the most are non-renewable sources that can be used up?"

Bring out obvious problem: continued reliance on fossil fuels, particularly oil and natural gas, will soon use up this source of energy. Other problems might be listed from newspaper and magazine sources.

4. In this or another lesson conclude mini-unit with discussion of possible alternative solutions to this problem.

Ask students to suggest solutions to the problem of declining supply of fossil fuels and increased demand for them as energy sources. Discussion should at least include possibilities of conserving non-renewable sources by not using as much energy as we do now and developing continuous sources to supply more of our energy needs.

Evaluation Suggestions

1. Using the following list, ask students to identify which items or activities use energy. Also, for each item or activity identify the characteristic (clue) that indicates energy is being used.

<i>Item or Activity</i>	<i>Is Energy Being Used?</i>
	Acceptable response
Table	No
Radio playing	Yes; light (dial), motion (sound is motion of air)
Electric clock running	Yes; motion
Overcoat	No
Food cooking	Yes; heat, light, motion (bubbling)
Car parked	No

2. Have students list the immediate and primary sources of energy for each activity below.

<i>Item or Activity</i>	<i>Immediate Source</i>	<i>Primary Source</i>
Stove or oven heating	gas or electricity	fossil fuel
Television playing	electricity	fossil fuel or solar hydroelectric or nuclear
Geyser erupting	geothermal	geothermal
Person riding bicycle	food	solar

3. a) Ask students to explain what is meant by a non-renewable energy source.

b) Have students list the five primary energy sources in descending order of present energy use.

c) Ask the students to label non-renewable sources (N) and continuous sources (C).

Acceptable responses:

a) Non-renewable energy source is one which is being consumed faster than it is being produced.

b. and c.)	fossil fuels	N
	solar energy (hydroelectric)	C
	nuclear energy	N
	geothermal	C
	tidal	C

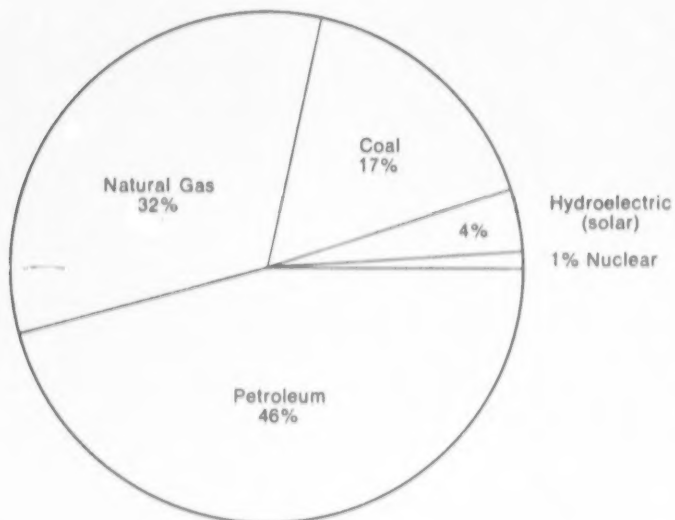
4. Ask students a) to describe one or more of the problems that might arise if we continue to obtain 95 percent of our energy from fossil fuels, and b) to list some steps to help solve the problem.

Acceptable responses:

a) Since fossil fuels are non-renewable, our continued and increased use will deplete our supplies, particularly of oil and natural gas. We will not be able to engage in many of our energy-using activities (heating homes and offices, cooking, lighting, and transporting people).

b) Conservation of energy—decrease demand and develop renewable sources of energy, such as solar energy.

TRANSPARENCY I
Where Do We Get Our Energy?



DATA SHEETS

Natural Gas, Oil, Coal, Electricity, Nuclear Energy,
Solar Energy, Geothermal Energy

Natural Gas

What Is It?

Natural gas, like coal and oil, is a fossil fuel. A mixture of gases, it is composed mostly of methane, an odorless, colorless, and tasteless gas that is lighter than air. A distinctive odorant is added to natural gas so that people recognize its presence. Conditions similar to those which produce oil also produce natural gas, and they are often, but not always, found together.

Natural gas and oil were formed, it is believed, out of the tiny plants and animals that existed on the land and in the water that covered much of the earth hundreds of millions of years ago. Gradually, the remains of these plants and animals were buried in layer upon layer of sand, mud, and other sediment. Time passed and the pressure, heat, and, perhaps, the action of bacteria and radioactivity changed these remains into oil and natural gas, which collected in layers of porous rock (see Diagram 1). Gas can move more easily through the porous rock than can oil and, as a result, there are many areas of natural gas not associated with oil.

Extracting Gas

Gas is extracted, or removed from the ground, by drilling wells. Geologists (scientists who study the earth and its outer layer) investigate land formations, looking for the kind of rock formations in which oil and gas have been discovered in the past. When a favorable location is found, a gas producing company will lease the mineral rights and proceed to drill a well (see Diagram 2). Drilling equipment is moved to the site and a derrick is erected. The drill bit, or cutting tool, begins to break up the rock and dirt between ground level and the area thought to contain the natural gas. After the dirt and rock are removed, a pipe is lowered into the hole. The average depth of natural gas wells drilled on land in the United States in 1972 was 5,679 feet. (The average depth for offshore natural gas wells was 10,698 feet.) There is never a guarantee that gas and oil will actually be located. Of the 28,449 oil and gas wells drilled from January to November 1974, 10,656 were "dry holes." If gas is found, it rises through the pipe to the surface where it is cleaned. After cleaning, it enters the transmission pipeline. Pumping stations along the way help maintain the pressure necessary to move the gas. It may travel thousands of miles to distribution systems and from there to individual homes or its many other points of use. By 1973, 967,667 miles of pipeline stretched across the United States. Of this total, 265,000 miles were transmission pipelines.

DIAGRAM 1

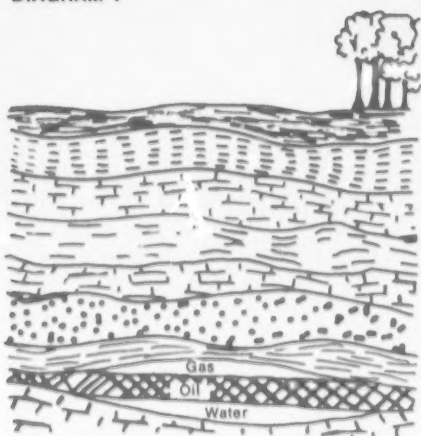


DIAGRAM 2

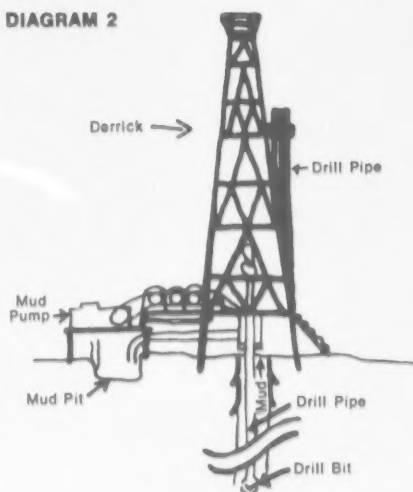
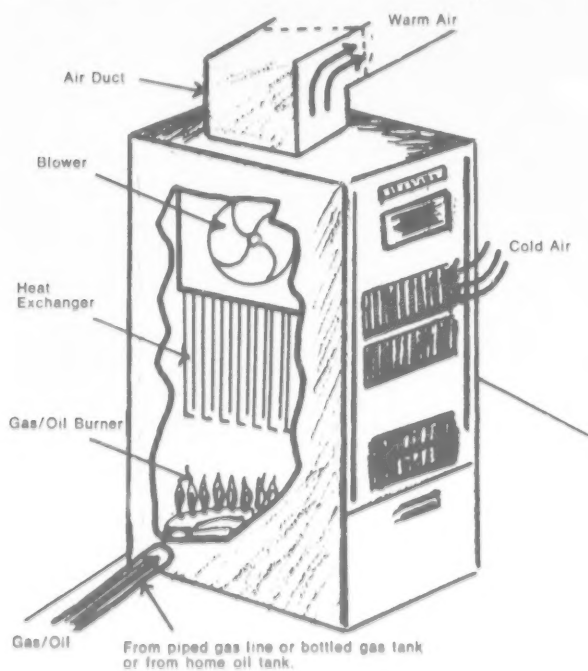


DIAGRAM 3



Natural Gas as Heat

Natural gas can heat a home directly or indirectly. A gas furnace can provide the heat that can be used to heat water or air (see Diagram 3). The hot water can be moved via pipes to radiators throughout the house, or the hot air can circulate heat throughout the house via air ducts. Natural gas can also be used to air-condition homes. As with other fossil fuels, it can be changed into electric power and be used to heat or to air-condition homes.

How Much Natural Gas Is Available?

In 1973 natural gas supplied about one-third (30 percent actually) of the nation's total energy. Its percentage share of total energy is expected to decline as new sources become harder to find. One prediction is that by 1990, natural gas will provide only one-quarter of our total energy. This smaller percentage, however, will correspond to more than half again as much gas as was consumed in 1973. It is, therefore, important to know how much gas we have left.

Some of our natural gas resources were wasted before it was learned how to store and transport the gas found during oil exploration. In the early 1900s, such gas was burned or lost—the know-how and equipment for transporting and using the gas supply were lacking. Between 1935 and 1955, however, a number of pipelines were built from the gas fields of the Southwest and other producing areas throughout the United States. It is now possible to extract and transport 80 percent of the natural gas found. (Coal is recovered at a 50 percent rate and oil at a 33 percent rate.)

Natural gas has been a preferred fuel during the last 50 years. It is clean, efficient, and causes only a small amount of pollution of the environment. In addition, the Federal Government, which regulates the price of interstate natural gas, has kept gas prices low. We have been using our natural gas supply at an increasing rate. In 1973, the people in the United States used 22.6 trillion cubic feet of gas. (A cubic foot is a block that measures one foot in length, one foot in height, and one foot in depth.) Until the 1970's, gas companies were seeking new customers and building new pipelines. By 1972, however, some gas companies began to refuse new customers and to occasionally interrupt the supply to their larger customers, such as schools and industries.

There is presently no way of knowing exactly how much natural gas, oil, and coal is buried in the earth. Geologists and other scientists concerned with such problems make estimates based upon their knowledge of geological formations that may contain these fossil fuels. These estimates are called "ultimately recoverable resources." For instance, the estimated "ultimately recoverable resources" of natural gas in the lower 48 states and Alaska at the end of 1973 were figured at 2,560 trillion cubic feet.*

* Estimates differ from source to source. These estimates come from Chapter 2, Volume II, of the NSTA *Energy-Environment Source Book*.

When drilling actually produces natural gas in an area previously designated as containing resources, and additional exploratory drilling reveals the size of the gas field, then data are available for a much better estimate of the quantity of natural gas in a given area. Such an estimate is then called a "reserve." Total reserves of natural gas in the lower 48 states and Alaska at the end of 1973 were estimated at 290 trillion cubic feet.

How long these supplies will last depends on how large they actually turn out to be, and on how much we use each year. If we were to continue to use natural gas at the 1973 rate of 22.6 trillion cubic feet per year, the ultimately recoverable resources would last 112 years and the reserves 13 years. If, however, our use of natural gas were to increase each year as fast as it did in the 1960's, even the ultimately recoverable resources would last only 45 years. To make sure that some natural gas is around for the next generation to use we must continue both to look for new supplies and to make sure that we use our present supplies efficiently—primarily for purposes demanding this clean fuel.

How Much Does It Cost?

As mentioned earlier, the United States Government regulates the price of interstate natural gas at the well. This has kept the price of natural gas low. The cost of heating using natural gas depends upon the size of the house, its geographic location, and the commercial cost of gas. In 1972, the average cost of heating a home with natural gas in our country was about \$150.00 (see Table, Regional Annual Average Residential Consumption and Cost of Natural Gas).

In addition a gas furnace can cost from \$250 to \$500 plus installation charges. It is likely that gas prices will increase in the near future.

Regional Annual Average Residential Consumption and Cost of Natural Gas

<i>Region</i>	<i>Gas Consumption (in Million British Thermal Units*)</i>	<i>Cost</i>
New England	89	\$202
Middle Atlantic	104	170
East North Central	164	197
West North Central	154	171
South Atlantic	102	147
East South Central	112	124
West South Central	101	89
Mountain	138	122
Pacific	111	121

Source: American Gas Association, 1972.

* BTU = 0.252 Calories of energy or 1 Calorie equals about 4 BTUs.

What Are the Environmental Effects of Producing and Using Natural Gas?

Natural gas in general has few harmful effects on people or the environment. It is basically a clean fuel, with practical no sulfur impurity and, therefore, contributes little to sulfurous smog. Like any fuel, when it is burned it will produce some of the nitrogen oxides that are part of the "photochemical" smog present in places like Los Angeles.

While safe for household use, natural gas does have explosive potential as the occasional leak-caused home explosion attests. It is not poisonous but can cause death by carbon monoxide poisoning if burned in a poorly ventilated room. About 100 people per year lose their lives from gas explosions and another 230 suffer from carbon monoxide poisoning due to gas fires.

Although many people prefer natural gas because it is clean and environmentally safe, it is presently our most limited fossil fuel resource and cannot be considered the answer to our long-term energy problem.

Oil

What Is Oil?

Oil is one of our most important fuels. In appearance it is a bluish-brown liquid about the consistency of table cream. It is called a fossil fuel because it was formed hundreds of millions of years ago when the seas were filled with tiny, one-celled animals called protozoans. Each protozoan lived in the sea inside a tiny shell and fed on very small sea plants. The unused food was stored in liquid form inside the shells. As these tiny animals died, they dropped to the sea bottom and layers of their remains were built up. With the passage of time, mud, sand, and other sediments buried these layers deep within the earth. Pressure and heat eventually changed the remains into what we now call "oil." It is sometimes found in a "pool" (as shown in Diagram 1), trapped along with gas and salt water under an impenetrable dome of rock. At other times it is not in a definable pool but is absorbed into the cracks and crevices of a porous rock formation.

Extracting Oil

Oil is found by exploratory drilling in an area where geologists (scientists who study the earth and its outer layer) determine that conditions are right for its existence. Equipment and men move onto the site, a derrick (see Diagram 2) is constructed, and well digging begins. There are three major parts of a well. The derrick is a steel structure about 100 feet high that helps raise, lower, and position the pipe. The rotary drill bits are huge, pipe-like steel cones covered with sharp teeth that cut up the rock and dirt so that it can be removed. The drill pipe is a steel pipe about four to six inches in diameter and about 30 feet in length. The drill pipe is rotated, or turned, into the ground by powerful engines. A mixture of water, clay,

and chemicals known simply as "mud" is forced through the pipe. This mud cleans and cools the bit and carries the cuttings to the surface. A drill bit can cut into the earth at a rate of about 40 feet per hour before the bit wears out. As the well gets deeper and deeper, additional sections of pipe are added. When a bit does break or wear out, the entire length of pipe must be pulled up and stored and the bit replaced, then the entire pipe is reassembled and lowered. The depth of the average oil well in the United States is about 4,500 feet. The complete job of replacing a drilling bit can take six men at least 10 hours—if all goes well.

Oil as a Source of Heat

Like any fossil fuel, oil must be burned to obtain energy. A sketch of a home oil furnace is shown in Diagram 3. Heat energy released in the burning of oil can be used in two ways: It can be used to heat water and then the water or steam moves into radiators throughout the house; or it can heat air, which circulates through air ducts located throughout the house. The heat from burning oil can also be changed into electricity in large power plants. This electric power can then be sent to homes to run air-conditioners or room electric heaters.

How Much Oil Is Available?

Oil supplied 46 percent of our total energy in 1974 and about half of this was used in transportation. Second only to natural gas in home heating, oil use is expected to increase. It is, therefore, important to know how much is left.

Because we imported so much of our oil, 40 percent in 1974, we have to distinguish between domestic resources—those in the continental United States—and world resources. With imported oil, it is the price rather than the amount in the ground that will be important.

As for our domestic resources, it is difficult to estimate them. We do not really know how much there is until we pump it from the ground. We not only need to discover oil, by exploratory wells such as we have described, but we need to be able to get it out of the ground. Present techniques allow us to get only one barrel out of every three that are in an oil deposit.

We will make the same distinction here that we made in discussing natural gas. We will talk about "ultimately recoverable resources," which are estimates, based on geological studies and the like, of the total amount of oil economically worthwhile and technically possible to recover, and "reserves," which is oil that is found and its extent measured. A present estimate is that there are 52 billion barrels of oil (one barrel is 42 gallons) in the reserve category and 502 billion barrels in the ultimately recoverable resources* category. In 1973 we used 6.3 billion barrels of oil in this country. If we obtained all of that oil from domestic resources and con-

* Estimates differ from source to source. These estimates come from Chapter 2, Volume II, of the NSTA *Energy-Environment Source Book*.

tinued using it at the same rate each year, our domestic reserves would last eight years and the ultimately recoverable resources would last 80 years. If we got only half of the supply from United States sources, these numbers would be doubled.

Our use of oil has, of course, been increasing each year, and if this trend continues the supplies will not last as long as current estimates. If our rate of use were to increase as fast as it did in the 1960's and we were to rely on domestic sources alone, even the ultimately recoverable resources would last only 35 or 40 years.

How Much Does It Cost?

The cost of oil is rising. The cost of an average oil well ranges from \$100,000 to \$3 million. Most of the oil that was easy to find has been discovered and wells constructed. Offshore and Alaskan sites are likely to be the major sources of oil in the future; as they will be in much harder places to work, their oil will be more expensive.

In 1964 fuel oil cost the consumer about 16 cents per gallon. By 1974 the price had doubled to 35 cents per gallon. Only a small part of the environmental cost of correcting pollution problems is included in the 35-cent price. As these environmental costs are added, we can expect the price of oil to increase some more.

The cost of heating a home with oil varies according to the size of the home, the geographic region, and the current price of oil. The average cost of heating a home with oil is about \$300 per year (estimate based on \$2.50 per million BTUs* at 1974 Washington, D.C., prices).

What Are the Environmental Effects of Producing and Using Oil?

Oil can harm the environment when it is produced, shipped, or burned. Although land-based wells and land transportation of oil can be messy, offshore or Arctic drilling for oil and its shipment by sea causes most of the environmental worries. Wells leak oil into the ocean or spill it in the occasional blowout. Tankers cleaning out their holds dump oil into the sea or spill it in an accident. In the Arctic, oil spills on the ice take a long time to disappear and pipes, such as the one being built across Alaska, can cause many changes in the land they cross.

Oil refineries, which process the oil to produce gasoline, heating oil, asphalt, and other products, create air and noise pollution as well as waste products, such as sludge and brine, that can create land and water pollution unless controlled.

Air pollution is a major problem. The burning of oil in furnaces adds harmful gases to the environment unless emission controls are added to the system. The Clean Air Act of 1970 has set standards for oil refineries and other manufacturing plants in an attempt to control the emission of harmful gases into the atmosphere. Plants may be fined or closed if they do not

* A BTU is a unit of heat energy equal to about one-fourth a Calorie. It takes about a 100 million BTUs to heat a home for one year.

comply with state regulations. At present no legislation has been passed to regulate air pollution from individual home furnaces. These harmful gases contribute to a variety of respiratory problems in people and animals.

The Water Quality Act of 1970 was passed to help regulate water pollution caused by oil spills and offshore oil drilling. The Federal Government has authority to conduct water clean-up operations and bill the responsible party later.

Regional Costs of Oil Heat

<i>Region</i>	<i>Amount (in Million British Thermal Units)</i>	<i>Heating Cost*</i>
New England	89	\$365
Middle Atlantic	104	328
East North Central	164	384
West North Central	154	294
South Atlantic	102	255
East South Central	112	216
West South Central	101	165
Mountain	138	269
Pacific	111	210

* \$2.50 per 1,000,000 BTU 1974, Washington, D.C.

Coal

What Is Coal?

Coal, like oil and natural gas, is a fossil fuel formed from the remains of vegetation. Half a billion years ago, the earth was warmer and wetter than it is now. Fern trees, huge mosses, and other tropical plants grew profusely in earth's swampy surface. They died and fell into the shallow water, building up layer upon layer. Cut off from oxygen by the water, much of the plant matter remained undecayed. As time passed this undecayed organic matter built up into the spongy substance we call peat (see Diagram 4). Dirt and sand washed down from the mountains and gradually buried the peat deeper and deeper. As the pressure compacted it and the heat increased much of the gaseous part, the hydrogen and oxygen were driven off and almost pure carbon was left behind—the hard, shiny black mineral we call coal. Now found in *coal beds*, seams usually 3 to 8 feet deep (although seams up to 100-feet thick are known), twisted by the folding of the earth's crust, coal is sandwiched between layers of shale, sandstone, or other kinds of rock as shown in Diagram 4.

Mining Coal

Coal is mined either on the surface or underground. In underground

mining, a hole is dug to the coal bed and gradually a tunnel large enough for men and machines to enter is cleared. Miners then begin the task of drilling and removing the coal. Coal is cut from the seams with automatic equipment. Shuttle cars or conveyor belts carry the coal to the surface, where it is processed and loaded on trucks or directly on railroad cars and sent to its destination. About half of all the coal produced in the United States is mined underground.

Surface mining, or *strip mining* as it is called, is used when the coal is located near the surface. Large power shovels and bulldozers remove the earth, rock, and vegetation above the coal seam, sometimes to a depth of 100 feet. Then smaller power shovels are used to remove the coal. Strip mining has become more important during the past decade and now about half of all domestic coal is produced in this way.

Coal as Heat Energy

When coal is burned, the sun's energy that was stored in the plants hundreds of million of years ago is released. Coal was once an important source of home heat, but now only a few coal-burning heating systems remain and most of these are in large buildings. When it is used to heat a building, the furnace system is similar to the one shown for oil; heat can be transported around the building by hot air, hot water, or steam.

The more important use of coal for heat is indirect. About half (46 percent in 1973) of the electricity we use is generated at coal-burning utility plants. This electricity can then be used to heat or cool houses and commercial buildings.

How Much Coal Is Available?

In 1974 coal accounted for only 18 percent of our total energy. We produced about 600 million tons of this fuel and exported 54 million tons to foreign countries. Since coal is our most abundant fossil fuel resource, its use is expected to increase; some experts predict that we will mine almost a billion tons of coal per year by 1980. It is thus important to know how much coal we have.

Coal deposits are much easier to find and map than are deposits of oil and natural gas. They are nearer the surface and are usually found where the geologists predict that they should be. The total coal which can be mined from known seams is given as 390 billion tons.* This is coal that is economically feasible to mine and counts only that 50 percent which will be extracted. (Present techniques leave about half the coal in the ground.) If we use coal at the rate we did in 1974, these reserves will last about 650 years. If our uses increases 5 percent per year (this means our consumption will double every 14 years), the coal reserves will only last 70 years—not even coal can last forever.

* Estimates differ from source to source. These estimates come from Chapter 2, Volume II, of the NSTA *Energy-Environment Source Book*.

DIAGRAM 4

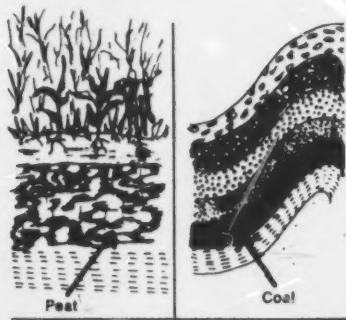


DIAGRAM 5

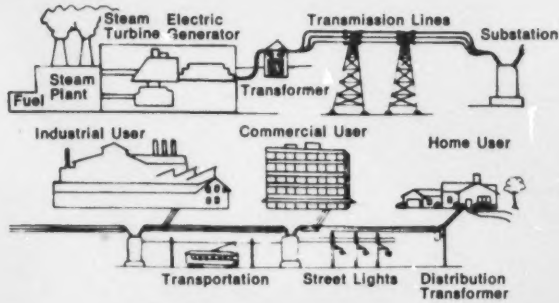
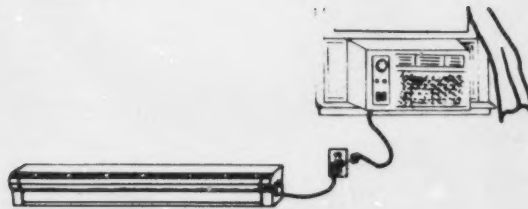
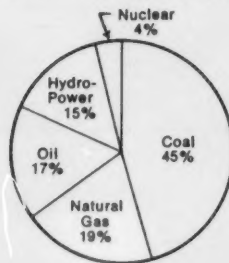


DIAGRAM 6



Graph 1
Fuels Which Produce Electric Power



How Much Does It Cost To Heat with Coal?

As we said earlier, coal is no longer used to any great extent in home furnaces. Still, some idea of the cost is helpful and is given in the table below, using 1974 coal prices in Washington, D.C. On the average it would cost \$244 per year to heat a home by coal.

The cost of coal will no doubt rise. Not only are labor, machinery, and other production costs rising, but environmental and miner health costs must also be added. Mine safety is being improved, payments to miners with "black lung" (a respiratory disease caused by inhaling coal dust) are now being made by coal companies, and stricter land reclamation laws may add several thousand dollars per acre to production costs. All these increases, however, will add only a dollar or so to the price of a ton of coal, and it will probably remain our cheapest fossil fuel.

What Are the Environmental Effects of Producing and Consuming Coal?

Coal mining is harmful to the environment in a number of ways. When strip or surface mining is used, huge shovels—200 feet tall, weighing millions of pounds—and other equipment move trees, shrubs, grass, and topsoil to get at the coal underneath. This is a cheaper way to harvest coal than underground mining and usually yields a higher percentage of the coal in the seam, 80 to 90 percent, than the 50 percent yield from underground mining.

Strip mining leaves the ground turned up and desolate. The exposed, bare ground, if it is on a hillside, is easily eroded and the silt and acid (formed when water combines with sulfur impurities) damage vegetation and stream life. On arid land it may take years for any vegetation at all to return.

The strip-mining picture is improving in this country. All states now have laws that require the restoration of mined lands, and the enforcement of these laws is becoming more vigorous.

Coal mining has also been costly in terms of human life. It is considered the most hazardous occupation in this country; 152 miners were killed in 1973. New coal mine health and safety regulations are being enforced, making the mines safer. The 152 miners killed in 1973 was a much better record than the 250 killed in 1970.

In addition to the mine accidents, many miners have been afflicted with black lung disease. It is estimated that as many as 125,000 miners may have this life-shortening illness and that it contributes to some 3,000 to 4,000 deaths per year. The new health and safety laws call for regulation in this area and measurement of dust levels in mines already show that coal dust is below the designated maximum level.

Regional Costs of Heating with Coal

Region	Amount (in Million British Thermal Units)	Cost
New England	89	\$175
Middle Atlantic	104	204
East North Central	164	322
West North Central	154	302
South Atlantic	102	201
East South Central	112	219
West South Central	101	198
Mountain	138	271
Pacific	111	218

Figures based on \$51 per ton, 1974 price, Washington, D.C. 1 ton coal = 26 M BTUs

Coal also causes problems when it is burned. Most coal contains a chemical called sulfur that, when it is burned, creates a gas which escapes up the smokestack and contributes to the smog we sometimes see over cities in the winter. This smog can be harmful to people and other living things. And soot from burning coal is one of the causes of the dirt and grime that cover our cities. The new clean air laws cause utility companies to employ emission control devices. Most electric power plants now have equipment that removes 99 percent of the soot from the smokestack fumes and equipment is coming into use that can take out most of the sulfur also.

Since our supplies of coal are much greater than the supplies of the other fossil fuels, oil and natural gas, scientists and engineers have developed means for creating synthetic or manufactured gas from coal. While the environmental effects of mining coal would not be reduced, the "gasification" of coal could add to our supplies of natural gas and decrease the contribution coal makes to our air pollution.

Electricity

What Is Electricity?

We call electricity an intermediate form of energy. It is not stored energy, such as the fossil fuels or uranium, and it is not in the form in which it finally appears as work or heat. Stored, or potential, energy is converted to electric energy by the processes described below. Electric energy then must be converted by a motor or a heater in order to be used.

Electric energy comes out of the following processes:

- 1) A fuel such as coal, oil, or natural gas is burned and heat energy is released. (Nuclear energy is also converted to heat energy.)
- 2) Heat energy is used to produce very hot steam.
- 3) The steam turns a steam turbine, converting heat energy to mechanical energy.

4) The turbine turns an electric generator, converting mechanical energy to electric energy.

5) Electric energy is transformed to very high voltages in a transformer and transmitted to substations and around the country on high-voltage transmission lines.

6) From the substations, the electric energy is transformed to appropriate low voltages and distributed by wire to offices, industrial plants, homes, and the like, where it is converted to heat, light, or mechanical energy by a variety of electrical devices.

The entire process is shown schematically in Diagram 5.

Electric power for heating and cooling: Homes are wired to carry electric current throughout the house. This electric power can then be used to heat and cool the home, to power appliances such as washers, dryers, TVs, and toasters, or to provide light. To heat a home electrically, base-board heaters containing electric coils can be placed in each room, or larger space heaters can be used to heat a room (see Diagram 6). To cool a home, a centrally-located air-conditioner can be used to circulate cool air through air ducts or individual air-conditioning units can be placed in various windows to cool rooms.

How Much Electric Power Is Available?

The amount of electric power that can be produced depends upon two factors: available fuels and available generators. In 1973, 81 percent of our electric power was produced by burning fossil fuels (see Graph 1). This poses a problem. Our domestic supply of natural gas and oil is diminishing and imports of these fuels are becoming more expensive. The estimated lifetimes of our various fossil fuels is summarized in Table 1. This table tells us how long they will last if each year we use the amount we used in 1973. Since we are actually using them faster than this, they will probably not last this long. The Federal Power Commission predicts that nuclear power will be providing 40 percent of all electric energy by 1990. In addition, methods of converting solar energy into electric power are being investigated. Only coal can be considered a possible long-range energy resource, and increased use of coal will reduce the supply more quickly than we presently predict.

TABLE 1
Predicted Lifetimes of Fossil Fuels^(a)

Coal	650 years
Oil ^(b)	180 years
Natural Gas	110 years

(a) Lifetime calculations assume consumption continues at 1973 rate and are based on "ultimately recoverable resources" rather than known "reserves."

(b) Based on continued importing of 45 percent of oil consumed. If only domestic oil is consumed, the lifetime would be 80 years.

In addition to the need for an adequate fuel supply, electric energy is limited by the number of power plants which can generate electricity. There are presently about 3,000 power plants in the United States. A generator consists of many coils of wire placed between the north and south poles of a magnet. Steam moves the turbine, which spins the coils of wire and causes electric current to flow. It requires four to seven years to build a typical large generating plant. Each generator has a peak capacity (upper limit) for producing electric power. In 1974 the total generating capacity of all electric plants was about 500,000 megawatts* of electric power. By 1990 this figure is expected to be 1,260,000 megawatts—almost three times as much. Modern generator capacity ranges from 1,000 to 3,000 megawatts. (A 3,000-megawatt generator could power Washington, D.C.) We will need at least another 300 generating plants by 1990.

What Does Electric Energy Cost?

Electric energy use has grown because the price for electricity has actually decreased over the years. In 1940 the average electric energy cost was 2.2 cents per kilowatt-hour. (A kilowatt-hour can power a 100-watt lightbulb for 10 hours.) In 1968 it cost, on the average, 1.5 cents per kilowatt-hour. Since 1971, however, the price of electricity has been increasing. The average cost of heating and electrically-powered home in 1972 was estimated to be between \$500 and \$600 for the year (see Table 2).

The cost of building an average electric power plant is now more than \$500 million. Many experts believe that the days of declining costs are over. As fossil fuel costs rise, electricity costs are also likely to rise. We can expect electric power to be available if we are willing to pay the price for it.

What Are the Environmental Effects of Producing and Consuming Electricity?

Electric energy today depends largely upon the fossil fuels—coal, oil, and gas. Whenever a fuel is burned to create the steam which produces electricity, much of the heat created by burning the fuel is lost. The best electric plants convert 40 percent of the fuel's energy into electric energy, allowing 60 percent to become wasted heat. About 10 percent of this heat loss leaves the plant as hot gas while the rest is discharged into the cooling water and enters nearby rivers or lakes. This increase in water temperature does not directly affect the health of people, but it can affect the marine life in the body of water it enters. Some of these effects are considered beneficial for the marine life, but most are considered harmful. At a certain

* A watt is a measure of electric power; i.e., the rate at which electric energy is produced. A megawatt is one million watts. For reference, a typical football or baseball stadium uses about a megawatt of electric power for night lighting.

stage of development, an increase in water temperature can help eggs and young fish grow faster. However, increased temperature often results in a loss of the more desirable species of fish and stimulates the less desirable. Higher temperatures can also affect the migratory habits of fish.

In addition, higher temperatures increase water evaporation and help concentrate the minerals already present in water. In cold areas, the warmer waters would stimulate recreational use; while in already warm waters, they would make the waters' use undesirable.

The Water Quality Act sets the standards for water quality. This includes temperature regulation of our rivers, streams, and lakes. Each state specifies the allowable rate-of-change of water temperature. Most states set the maximum water temperature change at less than 5°F.

Utilities are seeking practical ways of using their waste heat for such things as heating commercial buildings or in industrial processes. It may also be employed in desalting water and in agriculture. They are also turning away from direct use of river or lake water to cooling towers. In these towers a smaller amount of cooling water is recirculated and cooling either by evaporation (the "wet cooling towers") or by cooling fins in contact with air (the "dry cooling towers"). The use of such towers might increase the cost of electric power 5 to 10 percent.

Besides increasing water temperatures, power plants burning fossil fuels add sulfur dioxide and other gases to the air, forming smog that is harmful to man, materials, and crops. It contributes to diseases such as bronchitis and emphysema. The Clean Air Act establishes and maintains regional, state, and local air pollution control programs and enforcement of its provisions is bringing about more control over utility emissions.

In addition to gases and heat, fly ash enters the air and deposits dirt on surrounding homes and factories. This can also affect health and possibly even the climate of a given region. Gases and fly ash are controlled by equipment capable of removing 99 percent of the particles from the air.

In transmitting electricity from generating stations to local customers, towers, utility poles, and miles of cable are needed. High-voltage transmission lines require 200-foot-wide rights-of-way and now occupy about four million acres in the United States. Lesser effects include above-ground interference with radio and TV reception and underground electric currents which may corrode sewer and water pipes.

In addition to the environmental problems caused by creating electricity itself, the effects produced by obtaining the fossil or other fuels for its generation must also be considered.

Electric power does, however, make many positive contributions to our society. It creates jobs for the people who extract and transport the fossil fuels, as well as other jobs in the power plant and along the transmission lines. It provides the power for industry, for most of our home appliances, and for most of our forms of entertainment—radio, TV, and movies, for instance. Electric power is largely responsible for the high standard of living and many of the luxuries we enjoy today.

TABLE 2
Regional Cost of Electric Power for Home Heating

Region	Amount (in Million British Thermal Units)	Cost*
New England	89	\$731
Middle Atlantic	104	656
East North Central	164	769
West North Central	154	589
South Atlantic	102	511
East South Central	112	432
West South Central	101	330
Mountain	136	539
Pacific	111	420

Source: Potomac Electric Power Company, Washington, D.C., 1974.

* \$5.00 per 1,000,000 BTU.

Nuclear Energy

What Is Nuclear Energy?

Many people believe that nuclear energy is the answer to our energy problems. Others feel that it is a threat to public safety. It has already begun to play a large role in our energy future.

Nuclear energy is created by a process called fission. In fission the atoms of Uranium 235 are bombarded inside a nuclear reactor by neutrons (see Diagram 7). This bombardment results in the splitting of the uranium atom into two smaller atoms. When the uranium splits, heat is released along with more neutrons to continue the process. Since nuclear reactors are very complex and require many safety precautions, they can not be used as direct sources of heat for individual homes. The heat produced in a large reactor, however, can be used to heat water which creates steam and generates electric power. In 1974 nuclear-electric power accounted for about 6 percent of our total electric power. The Federal Power Commission predicts that by 1990, 40 percent of all electricity will be powered by nuclear energy.

Nuclear reactors: The nuclear reactor provides the environment in which fission occurs and is controlled. It also recovers the heat that is used to produce the electricity. The major parts (see Diagram 8) of the reactor are:

- fuel, which is used in the fission reaction and produces the energy
- control elements, which set the rate of energy released
- cooling fluid, which removes the heat generated in the reactors

DIAGRAM 7

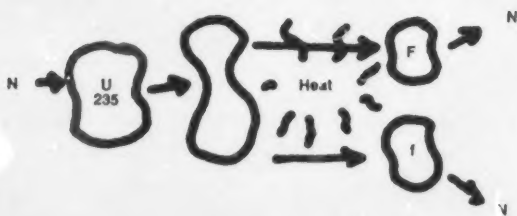


DIAGRAM 8

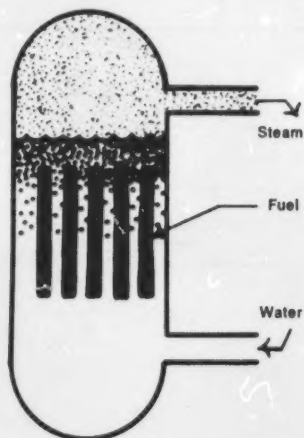
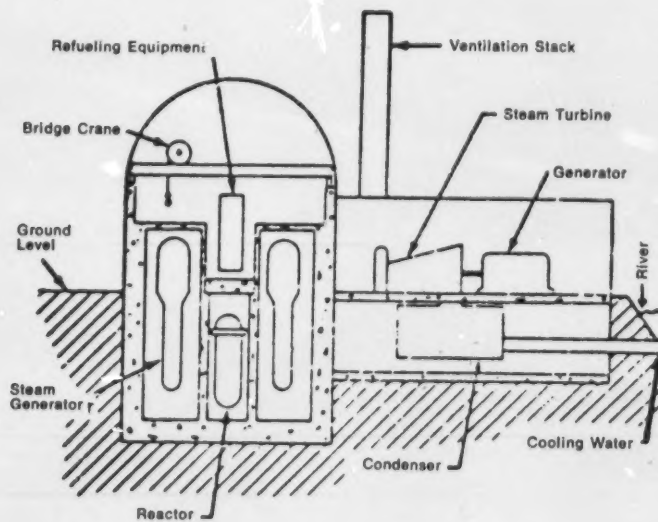


DIAGRAM 9



The nuclear plant: Today there are 50 licensed nuclear plants located in 26 states. The average plant costs \$600 million to construct, requires 4 to 6 years to build, and produces 1,000 megawatts of electric power. The plant design is determined by the kind of nuclear reactor used (see Diagram 9). Besides uranium, one of the important resources necessary for a nuclear plant is water. It is estimated that 330,000 gallons of water flow through a reactor *per minute*. A nuclear plant functions much like a fossil fuel electric plant. Both use steam to drive a turbine generator that produces electricity. The main difference is the way the steam is produced. In fossil fuel plants, coal, oil, or gas is burned to boil water to make steam. In nuclear power plants, nuclear fission produces heat which creates the steam.

Home use: Nuclear energy can be used indirectly to heat and cool homes. It is first used to produce electric energy, and then this electric power is sent to homes. In the home, electric baseboard heat or space heaters are used to provide heat, and electrically powered air-conditioners can be used for cooling the home.

How Much Nuclear Energy Is Available?

The basic fuel for nuclear energy is uranium, a somewhat rare mineral. As with other fuels, the amount of uranium available depends to a large extent on the price we are willing to pay for it (see Table 1). It is estimated that a typical nuclear power plant uses 130 tons of uranium to produce 1,000 megawatts of electricity. (A 1,000-megawatt plant could power one-third of the city of Washington, D.C.) The 50 plants in operation today produce 33,000 megawatts of electricity and use approximately 4,290 tons of uranium per year. At this rate, using the \$10-estimate figures from Table 1, the lifespan of our domestic uranium reserves would be about 220 years. Since we are using more and more each year, they will not last that long. In fact, if the growth of nuclear-generated electricity were to continue at its present rate, the consumption of electricity doubling every three years, the supply of under-\$10-per-ton uranium would only last about 30 years.

Scientists are working on a new reactor known as the breeder reactor. Breeder reactors are so named because they are able to produce a by-product, plutonium, which is itself a fuel. It is estimated that the breeder reactor can increase the lifetime and supply of nuclear fuels fifty-fold. Although breeder reactors are not being used today, they are likely to be developed and used in the near future.

How Much Does Nuclear Energy Cost?

Today the cost of producing electricity using nuclear power is similar to fossil fuel costs. The cost of heating and cooling with nuclear-electric power depends upon the size of the house, its geographic location, and the price of uranium. The average annual cost of nuclear-electric power to heat a home is about \$550 to \$600 (see Table 2 for regional costs).

How Does Nuclear Energy Affect the Environment?

Nuclear energy affects the environment in two main ways. On the one hand, there are environmental effects of mining and processing uranium. On the other hand, there are dangers to the environment and to people from the reactors themselves.

Effects of mining uranium: Uranium mining problems are similar to those of other types of mining. The miners are exposed to dust, accidents, fumes, and intense noise. The major concern, however, is the added presence of radioactive gas. Uranium is slightly radioactive and the U.S. Public Health Service has connected the relationship between exposure to radioactivity and lung cancer in humans. Uranium miners have higher rates of lung cancer than the general population. Controls for reducing the amount of radioactivity in the mines are being investigated. The waste materials from uranium mining are also dangerous and must be kept out of contact with living things.

Effects of nuclear reactors: There are two dangers from the reactors themselves. The leftover fuel material is highly radioactive and must be kept out of contact with living materials. There are about 45,000 gallons of radioactive waste produced for every 1,000 megawatts of electricity produced, and this must be stored somewhere for hundreds of years.

Large doses of radiation can seriously injure or kill human beings. Much less is known about the effects of the very small doses associated with the discharge from nuclear plants. Scientific opinion is, however, that even small doses do some amount of genetic damage and carry a low cancer-causing probability. Radiation levels from nuclear plant discharge are considerably smaller, at present, than are the levels we are exposed to from other man-made and natural sources.

The radioactivity associated with nuclear waste is potentially much more dangerous than that from plant discharge and for that reason it must be safely and securely stored. The final disposition of this material has not yet been decided, and more and more accumulates as the number of operating reactors increases.

The major concern about nuclear reactors is the possibility of an accident. While present-day reactors cannot explode like a nuclear bomb, there are possible malfunctions that can result in a small explosion. The spread of radioactive debris over the countryside would be a catastrophe.

In a recent study funded by the Atomic Energy Commission (this agency no longer exists and most of its functions are absorbed in the Energy Research and Development Agency ERDA), the probabilities of such accidents were estimated. The conclusion was that serious accidents are not very likely—only one chance in one billion of an accident causing some 2,000 deaths. Such an accident, however, could do as much as \$2 billion in property damage. These are risks which must be weighed into the cost of nuclear power.

TABLE 1
U.S. Uranium Resources

<i>Price Per Pound</i>	<i>Reasonably Assured Reserves (in tons)</i>	<i>Estimated Additional Resources (in tons)</i>	<i>Total (in tons)</i>
\$ 8.00	277,000	450,000	727,000
10.00	340,000	700,000	1,040,000
15.00	520,000	1,000,000	1,520,000

Atomic Energy Commission, 1974

TABLE 2
Regional Costs of Nuclear-Electric Energy

<i>Region</i>	<i>Heating Cost</i>
New England	\$409
Middle Atlantic	476
East North Central	751
West North Central	705
South Atlantic	469
East South Central	511
West South Central	462
Mountain	632
Pacific	510
Average	\$569

(Based on 1973 figures, 1,000 megawatt nuclear power plant—light water reactor, \$4.57 per 1,000,000 BTUs.)

Solar Energy

What Is Solar Energy?

Solar energy, sunlight or radiant energy, falls on the earth, providing both heat and light for plant and animal life. Scientists and engineers are just beginning to find practical ways to use solar energy to heat and cool individual homes. The United States Government is sponsoring several experimental projects which are investigating methods of collecting solar energy and converting it to electric energy. This solar-electric energy could then be used to heat and light entire communities.

Solar energy as a heat source: The present method of using solar energy to heat a home requires some type of collector which absorbs and traps the sun's energy. One side of the roof of a house might be converted into a solar collector similar to a very large "glass sandwich" (see Diagram 10). The "sandwich" has an outside layer of glass, a half-inch air space,

DIAGRAM 10

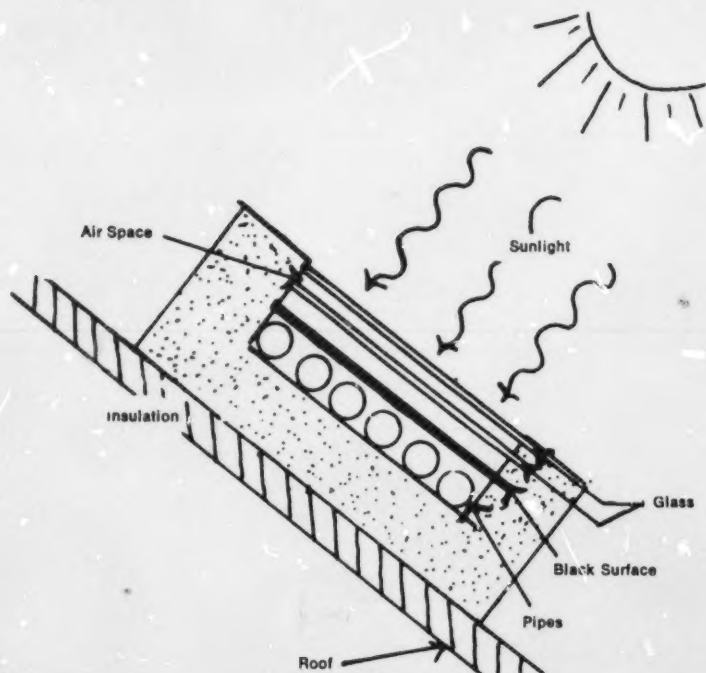
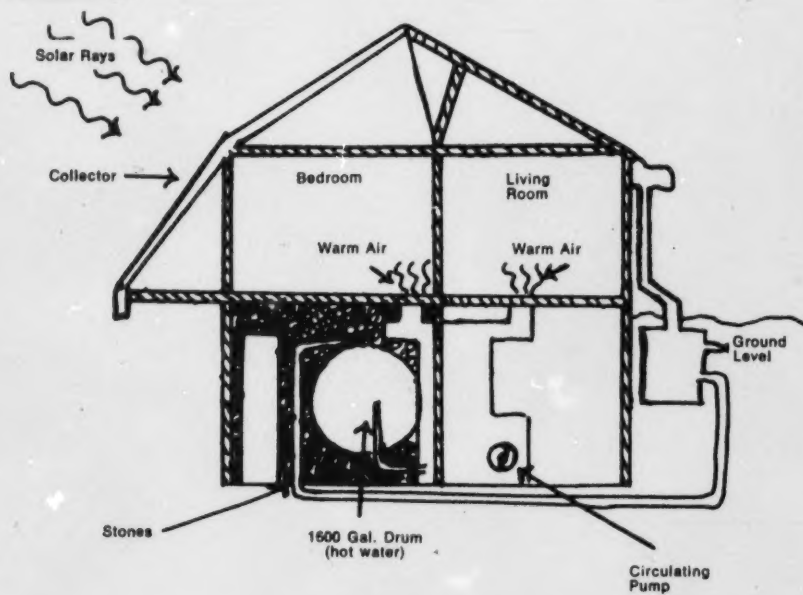


DIAGRAM 11



a second layer of glass, and a layer of aluminum painted black. The glass allows the sunlight to pass through to the black surface, which absorbs the light and is heated. This absorbed energy then heats water which flows over the black surface or flows through pipes directly behind the black surface. This hot water can then be piped to hot water radiators throughout the house or it can be used to heat air which is circulated through ducts throughout the house.

Using solar energy: A solar heating and cooling system is expensive to install now, but the rising costs of other fuels make solar energy one of our best hopes for the future.

A solar-heated home: Harry Thomason of Washington, D.C. has designed a workable solar heating system for an individual home (see Diagram 11). He made a solar collector by covering one side of the roof of his house with two layers of glass followed by a third layer of corrugated aluminum. He placed a 1,600-gallon water tank in his basement. This tank is insulated and surrounded on three sides by fist-sized stones. Pipes lead from the tank, across the basement, up the side of the house to the top of the roof. Water moving through a pipe trickles down the hot corrugated aluminum and becomes warm. This warm water flows into the tank, heats the surrounding stones which in turn heat the air. This warm air is then circulated by a fan throughout the house.

Mr. Thomason's storage system can provide heat for five sunless days. Average daytime temperature in the house is 72°F and the nighttime average is 68°F. A small furnace is kept in the basement for use during prolonged sunless periods. With certain changes this system can also be used to cool a house.

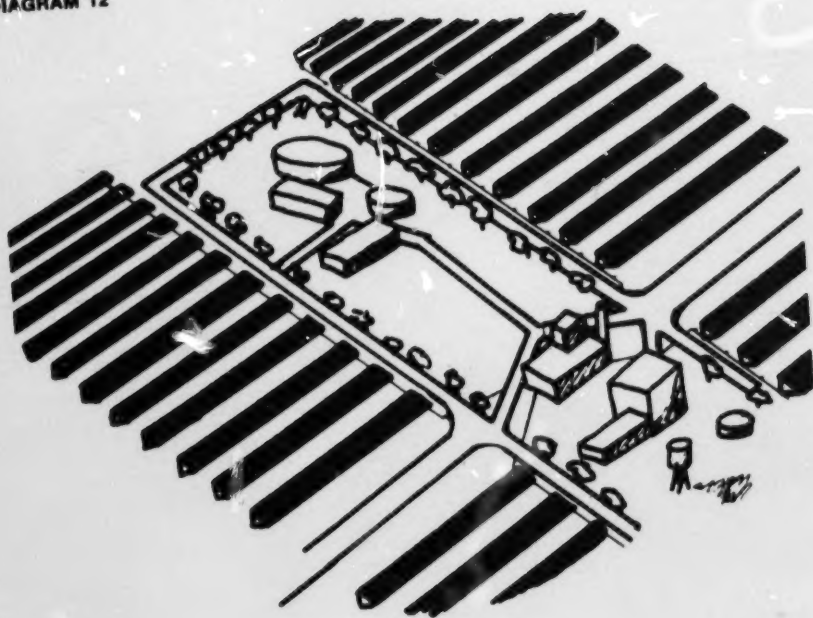
How Much Solar Energy Is Available?

Solar energy is the most abundant and continuous form of energy available to man. Much of the sunlight that approaches earth is reflected by the atmosphere back into space. It is estimated that only half of the solar energy from the sun actually reaches the ground. This is still a great amount of energy—roughly 810 kilowatts per acre. Only a small part of this is actually used by man. Sunlight not only provides light and heat but is indirectly the source of our food, winds, water power, and the fossil fuels. When scientists learn to successfully collect, store, and transport solar energy, they will have tapped the greatest energy source available to us.

What Does It Cost?

Solar heating and cooling systems are expensive to install but very inexpensive to operate. The Thomason system costs about \$2,500 to install but only \$6.30 a year to use. Local governments (the Washington area is one) and private companies are sponsoring research projects in hopes of finding less expensive systems for using solar energy. There are also research teams investigating practical methods for converting solar energy into electric energy which can be used to power entire communities.

DIAGRAM 12



The basic cost of operating a solar-heated home will vary according to the size of the house and the general climate of the region in which it is located. Colder regions would require greater use of the auxiliary heating system to maintain a 70-72°F house temperature.

What Are the Effects on the Environment?

Solar heating and cooling have no known harmful effects on man or plant life. If used in an individual home, the system can provide a clean form of heat without adding pollution to the surrounding air, land, or water. In order for solar heating to be widely used, however, we will need to find a way to make electric energy from solar energy. At our present level of technology, large tracts of land would be needed for solar collectors. Two physicists, Drs. Aden Meinel and Marjorie Mienel, have designed a model of a solar "farm" which could be used to collect solar energy and convert it into electric energy (see Diagram 12). They estimate that these solar farms would require 10,000 square miles of land to produce enough electricity for the entire United States. This would mean that about 25 square miles of land, or an area roughly equal to 1,000 football fields, would be needed to power Washington, D.C. (based on the 3,000-megawatt 1970 consumption rate).

If cheaper, more compact systems can be designed, solar energy is likely to be an increasingly popular form of energy in the future. It is probably one of the best alternatives to the long-term energy problem, but we are just beginning to understand its potential.

Geothermal Energy

What Is Geothermal Energy?

Geothermal energy is created by the natural heat of the earth. When the heat from the molten inner core of the earth meets the underground water, hot water or steam results. When this water or steam pushes through the surface of the earth, it creates either a hot water spring or a geyser (see Diagram 13).

People have used hot water springs as health baths for centuries, but only in the 1900's have natural steam and hot water been used for heating homes. In 1904 geothermal energy was first used in Italy to provide electricity. Hungary and Iceland started piping natural steam and hot water directly into homes in the 1930's. Finally, by the 1960's, New Zealand, Japan, and the United States started to build small power plants that used geothermal steam to generate electricity. Presently geothermal energy accounts for 0.1 percent of the world's electric power. The largest United States field, California's The Geysers, provides about 500 megawatts of electric power.

Tapping and Using Geothermal Energy

Geysers indicate that in the surrounding area hot underground water

DIAGRAM 13

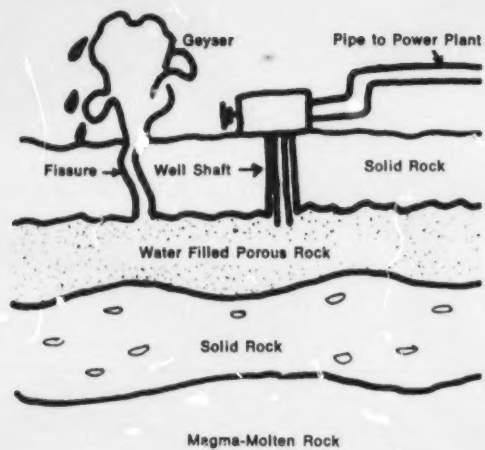
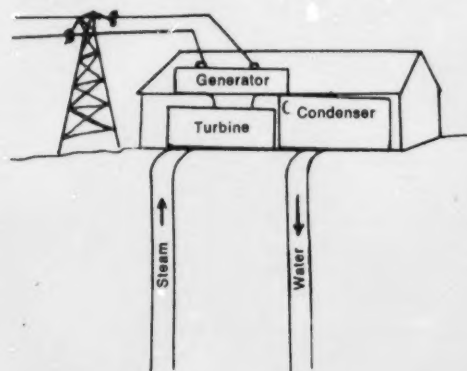


DIAGRAM 14



Map of Geothermal Regions



and steam are near the earth's surface. Once the geysers have been located, a geologist, a scientist who studies the earth and its outer layer, investigates the size, volume, and temperature of the geothermal system. If conditions are favorable, a well is dug near a geyser and the steam is channeled through large pipes to its destination (see Diagram 14). This natural steam may be piped directly to homes or to a nearby electric plant.

When natural steam is piped directly to a home, it fills hot water radiators and provides heat. More often today it is piped to an electric plant and is used directly to turn the turbines and generate electric power. Then this electric power is transmitted through wires into individual homes. Inside a home, electric power can heat either by using an electric hot-air furnace or by using electric space heaters. Electric power can cool by using individual air-conditioners or a centrally located forced cool air system.

How Much Geothermal Energy Is There?

At the present time geothermal energy provides 0.1 percent of our electric power and only isolated examples of direct steam power for homes. It is limited to those areas where geysers exist. In the United States, most of these areas are located in the Western states. Geothermal springs are located in Idaho, Nevada, Colorado, New Mexico, Oregon, Wyoming, Utah, and Montana (see map of Geothermal Regions). The more thorough survey now under way will, no doubt, locate many more sources not visible on the land's surface.

Steam is not easily transported long distances, therefore, geothermal-electric power plants are located on the geothermal sites. Relatively small, they service only the local area. The Geysers Plant in California provides half of San Francisco's electricity.

How Much Does It Cost?

One of the most attractive qualities of geothermal energy is its low cost. The initial costs of locating reservoirs of natural steam are fairly expensive, but natural steam itself is very inexpensive when compared to nuclear and fossil fuels. Natural dry steam (steam without any water droplets) is available at about \$0.70 per million British Thermal Units (BTU).^{*} If steam is piped directly to individual homes, the average cost of heating with dry natural steam would be about \$92 per year.

When dry natural steam is used to create electric power, it is also less expensive than nuclear or fossil fuels. An estimated cost for geothermal electric heat for the average American home would be about \$200 per year (see Table, Regional Cost of Geothermal Electric Energy).

This is about one-third the cost of oil-generated electric heat and one-half the cost of nuclear-electric heat. So the relatively low cost of geothermal-electric heat makes it a desirable alternative for heating and cooling homes where it is available.

^{*} 1 BTU = one-fourth of a Calorie.

How Does It Affect Our Environment?

The use of geothermal energy can have adverse effects on the surrounding land area and on the people and animals who live there. Most geysers and hot water springs are present in scenic areas with unique landscapes. Yellowstone National Park is one area where geysers, such as Old Faithful, are located. People often object to "spoiling" these landscapes with geothermal wells. Tapping geothermal energy would require the construction of roads, ponds, wells, large above-ground pipes, and an electric power plant. In addition, geothermal wells require a ventilating system to prevent the loss of the well due to condensation. Noise from an unmuffled well has been compared to a jet plane on takeoff. When the steam and fluids of a geothermal reservoir are removed, the ground may subside, or sink, a little. In residential areas this would create problems. One solution to this is to pump the used water and fluids back into the earth after they have been used.

Geothermal energy also affects the water and air. Poisonous or highly salty geothermal fluids can pollute streams, ponds, and ground water. In addition, the heat added to the water can be fatal to marine life. Certain gases, such as ammonia and carbon dioxide, which are released from the wells, can cause serious air pollution in the local areas. These pollutants will have to be controlled at the well.

Although people, wildlife, and marine life are affected in various ways by geothermal energy, it does not create as many problems as fossil and nuclear fuels. Geothermal energy can be used directly and does not require processing plants for fuels. It does not require major land disturbances, such as mining, when extracting the fuel. It also does not create as many problems with waste disposal as do the fossil fuels. It produces a basically clean heat. For these reasons it is considered a desirable source of energy where it is available.

Regional Cost of Geothermal Generated Electric Energy (Estimated)

<i>Region</i>	<i>Regional Use (in Million British Thermal Units)</i>	<i>Regional Cost</i>
New England	89	\$138
Middle Atlantic	104	162
East North Central	164	254
West North Central	154	239
South Atlantic	102	158
East South Central	112	174
West South Central	101	157
Mountain	138	214
Pacific	111	172

Source: Bureau of Mines, U.S. Department of the Interior, 1974.

Evaluation Suggestions

1. Ask the student to name three* or more energy sources that we could use to heat and cool our homes and offices.

Acceptable response:

Three or more of the following—coal, oil, natural gas, nuclear, solar, geothermal, electricity.

2. Ask the student to identify two* or more factors which might influence his/her choice of an energy source for heating or cooling homes in his/her community.

Acceptable response:

Two or more of the following—cost, availability, environmental effects, and others which differentiate sources.

3. Ask students to write an essay entitled, for example, "My Choice of an Energy Source to Heat and Cool My Community." The student may be judged as having achieved the objective if in the essay—

- (a) one of the seven sources described in the mini-unit is chosen
- (b) several factors are mentioned which the student regards as important
- (c) the energy source chosen ranks among those which have the most advantages and fewest disadvantages of the factors mentioned.

4. Pose an additional decision problem to students and ask the students to research and report on one of the alternatives. The problem may be as simple as: "Which movie, book, or magazine should the class see or read?" In this case the student might review and report on one of the alternatives after the class determined the factors in which it was interested.

The problem may also be more involved. For example, you might pose as another mini-unit investigation: "Which form of transportation should we use in our model community?"

The student may be judged as having accomplished objective 4 if, in additional problems such as these, the student presents pertinent information to the group with less aid from the teacher in researching and reporting than in previous group decision-making activities.

5. Ask the student to list three or more components of a group's decision-making process.

Acceptable responses:

Three or more of the following should be mentioned in their correct order: (1) define the problem; (2) plan a method for approaching the problem and identify alternative choices; (3) gather and evaluate information; (4) decide and act; (5) evaluate the decision made.

* Achievement criterion which may be varied by the teacher.

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Books:

Let's Go to An Atomic Energy Town, Kirk Polking (New York: Putnam) 1968.

Power and Energy, Frank Ross (New York: Lothrop, Lee & Shepard) 1967.

The Whole Earth Energy Crisis (New York: Putnam) 1973.

Articles:

"The Fascinating Story of Fossil Fuel," Isaac Asimov, *National Wildlife* 38 (4), August-September 1973.

"Geothermal—the Devil's Own Breath," *Conservation News* 38 (23), December 1973.

"The Search for Tomorrow's Power," *National Geographic*, November 1972.

"Coal Is Cheap, Hated, Abundant, Futhy, Needed," Jane Stein, *Smithsonian*, February 1973.

Free or inexpensive materials:

American Gas Association, Educational Services, 1515 Wilson Boulevard, Arlington, Virginia 22209.

Booklets #N00160 and N00165:

"Natural Gas Serves Our Community," 28 bulletin board pictures and descriptive booklet.

"The Story of Natural Gas Energy," 48 pp., 50 illust.

Channing L. Bete Co., 45 Federal Street, Greenfield, Massachusetts 01301, 25¢ each 1-99 copies; may be available from your local power company. Sample titles:

"ABC's of Electric Power from the Atom"

"Electric Power"

"About Coal Gasification"

Concern Inc., 2233 Wisconsin Avenue, N.W., Washington, D.C. 20007, "Eco-Tips #7 Energy Alternatives"

Data cards on:

Fossil fuels—\$10.00 per hundred

Nuclear energy—\$12.50 per hundred

Solar energy—\$12.50 per hundred

Geothermal energy—\$7.50 per hundred

Interstate Oil Compact Commission, Educational Department, P.O. Box 53127, Oklahoma City, Oklahoma 73105, "Oil for Today and for Tomorrow."

National Coal Association, 1130 17th Street, N.W., Washington, D.C. 20036, "Coal," 24-page reprint from *World Book* article and "Coal in Today's World."

U.S. Department of the Interior, "Indivisibly One," *Conservation Yearbook Series*, #8, USGPO \$2.00 (SN2400-0751) section on energy.

U.S. Department of the Interior, Bureau of Mines, Publications Distribution, 4800 Forbes Street, Pittsburgh, Pennsylvania 15213. One copy of up to 10 chapters in

booklet form from book *Mineral Facts & Problems* (must be requested on official stationery). Sample topics: anthracite, energy resources, natural gas, petroleum, shale oil.

U.S. Department of the Interior, Geological Survey Information Office, Reston, Virginia 22092, "Natural Steam for Power."

Films:

The American Dream is Running Out of Fuel, 18 minutes, color, \$230 or \$19 rent. Films Inc., 1144 Wilmette Avenue, Wilmette, Illinois 60091.

Atomic Power Production, 14 minutes, color. Handel Film Corporation, 8730 Sunset Boulevard, Los Angeles, California 90069.

Flames & Energy, 37-frame filmstrip, free. Educational Services. American Gas Association, 1515 Wilson Boulevard, Arlington, Virginia 22209.

Natural Gas — Energy in the Home, 16 mm, sound 13½ minutes, free. American Gas Association, 1515 Wilson Boulevard, Arlington, Virginia 22209.

Our Minerals & Energy Resources, 1970 filmstrips, sound, \$10. Coronet Films, Division of Esquire, Inc. 65 East South Water Street, Chicago, Illinois 60601.

Our Mr. Sun Parts I & II, 60 minutes, color, Pacific Northwest Bell.

Part I, Sun as Ancient Man Saw It.

Part II, Efforts to Harness the Sun's Energy.

Note: Additional references to books, articles, and films are provided in the NSTA *Energy-Environment Materials Guide*.

Materials List

- Collect, or have students collect, cartoons, headlines, newspaper articles, brochures, etc. on energy-environmental problems and on the seven sources of energy discussed in the mini-unit (coal, oil, natural gas, electricity, geothermal, solar, nuclear).
- Prepare a bulletin board of these materials.
- Duplicate enough copies of each of the seven enclosed data cards on energy sources so that each student in the corresponding research group has a copy. (about 4 to 5 copies of each for a class of 30)
- Duplicate a copy of the Energy Summary Chart for each student.
- Have available materials to aid presentation of student reports such as poster paper, magic markers, etc.

Energy Curriculum

Lesson Plans

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The following lesson plans are excerpted from a course entitled *Energy*. It was developed by Fred Posthuma, a teacher at Westfield High School, as part of the course offerings for Industrial Education (a part of the total school curriculum offerings K-12) in the Unified School District of Westfield, Wisconsin. The course is designed for students in grades 9-12.

General course objectives are:

1. To work and experiment with energy systems in order to gain an understanding of energy sources, conversion, transmission, storage, and control.
2. To understand the interdependence of society and the availability of energy.
3. To provide an opportunity in which students can gain career information for entry into energy-related occupations.
4. To develop positive attitudes in relation to safety and work habits.
5. To provide an opportunity in which students can gain an insight into the environmental effects of energy.
6. To develop positive attitudes relating to use and conservation of energy.
7. To develop problem-solving and creative techniques in working with energy systems.

The course is comprised of one hundred eighty hours of instruction, testing, and hands-on activities, in addition to whatever outside time is

required to complete homework assignments. Classes are conducted on a one-hundred-eighty-day basis with units of study organized into successive time slots throughout the school year.

The lesson plans are an integral part of the Energy curriculum. Those presented here cover the Energy Dilemma, Present Resources, Pollution and the Environment, and Alternate Sources of Energy. Audiovisual materials to be used with the overhead projector may be teacher-made or drawn from pertinent sources. For each lesson plan references are given for books, magazines and journals, pamphlets, films, and slides and filmstrips. The list appears on page 136. References are designated B1 (Book 1), M1 (Magazine 1), P4 (Pamphlet 4), etc.

Lesson No. 1

Subject: Energy Dilemma

Assignment: None

Objective: To enable the student to form attitudes and opinions about the energy dilemma as evaluated in lecture and discussion with the instructor.

Time: One hour

Teacher Activity: Lecture, discussion

Student Activity: Discussion, notes

Materials needed: None

Audiovisual: Overhead projector

- I. Review of previous lesson
 - A. Questions
 - B. Quiz on energy model
- II. Energy Crisis
 - A. Do we have an energy crisis?
 - B. Beginnings (late 1972)
 - 1. School closings prompted by oil shortage
 - 2. Sunday closings of service stations
 - 3. Surge in small car sales (40%)
 - C. Full impact (1973)
 - 1. Gas company cutbacks

- 2. Voltage reductions
- D. Effect on consumer
- III. Responsibility
 - A. Three targets
 - 1. Government (regulation)
 - 2. Energy industry (holding back)
 - 3. Environmentalists (halting wheels of progress)
 - B. Friction between them
- IV. Results
 - A. Demand outruns supply
 - B. Rise in imports
 - 1. Changeover to oil by utilities
 - a) Pollution (sulfur from coal)
 - b) Natural gas price hikes
 - 2. Automobile industry
 - a) Accounts for 40% of oil consumed in U.S.
 - b) Less efficient converters of gas into vehicle miles
 - c) Power-consuming accessories
- V. Energy Pie
 - A. Industrial (40.2%)
 - B. Commercial (14.9%)
 - C. Residential (19.8%)
 - D. Transportation (25.1%)

VI. Summary

References: * B2, B7, P6

* See p. 136.

Lesson No. 2

Subject: Present Resources

Assignment: Research paper on present resources available

Objectives:

1. To enable the student to form attitudes and opinions about energy resources as evaluated in lecture and discussion with the instructor.
2. To enable the student to complete (after research and lecture) a paper on present resources and their future outlook.
3. To enable the student to accurately answer related test questions.

Time: Two hours

Teacher Activity: Lecture, discussion

Student Activity: Notes, discussion, research

Materials needed: Assignment sheet

Audiovisual: Overhead projector

- I. Review of previous lesson
 - A. Questions
 - B. Hand in assignment
 - 1. Discussion
- II. Present energy sources
 - A. Organic (fossil) fuels
 - 1. Plants and animals buried millions of years ago
 - B. Nuclear fuels
 - 1. Uranium 235 and 238
 - 2. Plutonium
- III. Basic historical ladder
 - A. Wood
 - 1. Renewable resource
 - a) Planting and harvesting schedule
 - B. Animal wastes
 - 1. Buffalo and cow chips
 - C. Coal
 - D. Petroleum products
 - 1. Oil
 - 2. Gas
 - 3. Other
 - E. Nuclear
 - 1. Application of fission
 - F. Other technologies
 - 1. Breeder reactors
 - 2. Fuel cells
 - 3. MHD generators (magnetohydrodynamic)
 - 4. Other
- IV. Oil in the United States
 - A. Decrease from 44% to less than 19% in world crude oil produced in the United States (overhead).
 - B. Increase in Middle East production from 24% to over 45%
 - C. Decrease in total number of producing wells in the United States
 - D. Decrease in exploratory wells from 16,000 to 8,000 per year

- E. Control
 - 1. Small businesses
 - 2. Large conglomerates
 - a) Possible price control
- F. Increased drilling
 - 1. Insufficient number of rigs
 - 2. Increased cost of steel
 - 3. Limited manpower
 - 4. Lack of attraction to oil drillers (in terms of input capital to output capital received)
- G. Over one-half of oil in the United States and territorial waters discovered
 - 1. New techniques required for offshore drilling
 - 2. Problem of oil spills
- H. Greatest possibility will be found in offshore territorial waters and in Alaska
 - 1. Alaskan pipeline (completed June 1977)
 - a) Total cost (8 billion?)
 - b) Cost more than imported oil
 - c) A rip-off?
 - 2. Governmental regulation and policies
- V. Oil recovery
 - A. Future recovery (about 30% of what is found)
 - 1. Efficiency of recovery systems poor
 - 2. Economic factors
 - 3. Governmental regulations
 - 4. Nature of oil occurrence
 - B. Nature of recovery
 - 1. Oil contained in interstices of rocks
 - 2. Porosity of reservoir not more than 30%
 - 3. Oil and water mixed and must be separated
 - 4. Rate flow slow because of viscosity
 - C. Past recovery
 - 1. One in ten exploratory wells have enough oil to justify production
 - 2. One well in fifty has sufficient oil reserves to repay total cost
 - 3. Secondary recovery techniques poor and expensive
 - a) Water injection
- VI. Gas resources
 - A. Estimates
 - 1. United States Geological Survey (USGS)
 - a) 1,000 to 2,000 cubic feet
 - 2. Mobil Oil Company
 - a) 443 trillion cubic feet (computer estimate)
 - B. Differences
 - C. Cleanest burning fossil fuel (32% of total energy)

VII. Coal

- A. Supplies about 18% of our energy
- B. Most abundant of our fossil fuels
- C. The United States has about one-third of world's coal supply
- D. The United States has about 500 years' worth of power reserves at current consumption
- E. Much coal high sulfur (pollutes air when burned)
- F. Most low sulfur coal located in Western states
 - 1. Emission standards can be met by burning 1% or less sulfur
 - 2. High sulfur 3% to 6% sulfur
 - 3. Cost per ton about \$10

VIII. Nuclear energy

- A. Process of fission (brief explanation)
- B. Supplies only about 1% of our energy and 4% of our electrical generating capacity
- C. One ton of nuclear fuel equals same heat energy as 2,300 tons of coal or 300,000 gallons of kerosene
- D. Heat created is 3 million times as hot as conventional coal-fired furnaces
- E. Problems
 - 1. Thermal pollution
 - 2. Radioactive wastes
 - 3. Safety
 - a) Existing plants have excellent safety records
- F. Breeder reactor
 - 1. Makes own fuel (plutonium)

IX. Hydroelectric power

- A. Accounts for about 4% of our energy
- B. Limited amount of falling water
- C. Concern for environment limits construction of new dams

X. Summary

- A. Assign research paper on present resources available due in three days
- B. Assign students to bring various types of fuel for fuel-burning exercise tomorrow

References: * B2, B7, B10-11, M1-2, P4, P11

* See p. 136.

Lesson No. 3

Subject: Pollution and the Environment

Assignment: Paper, one page or longer, on pollution

Objectives:

1. To enable the student, through lecture and discussion, to list four types of pollutants and explain each as evidenced by completion of a quiz with 100% accuracy.
2. To enable the student, with the aid of references, to prepare a paper of not less than one page on the subject of pollution in relation to energy and the environment. Evaluation to be by the instructor and peers.
3. To enable the student, given various fossil fuels or by-products, to make a comparison of each fuel by preparing a chart which will be evaluated by the instructor.

Time: One hour

Teacher Activity: Lecture, discussion, demonstration

Student Activity: Notes, discussion, paper

Materials needed: Assignment sheet, fuel-burning exercise

Audiovisual: Overhead projector

- I. Review of previous lesson
 - A. Questions
 - B. Discussion
- II. What is pollution?
 - A. Two types
 1. Atmospheric
 2. Nonatmospheric
 - B. Smog formation
 1. Formed during precise ecological condition
 2. Burned fuels produce oxides of nitrogen
 - a) Warm layer of air contains oxides
 - b) Smaze
 - c) Happens only on overcast days
 3. Photochemical smog
 - a) Only in presence of direct sunlight
 - b) Sunlight and nitric oxides combine with other particles in the air such as dust and unburned carbon exhaust

III. Nonatmospheric pollutants

A. Noise

1. Stimulates
2. Depresses

B. Dust

1. Dust storms

C. Thermal

1. Least noticed but most devastating
2. Can cause disturbance in weather
3. Accelerates algae growth
4. Kills fish
5. Nuclear generating plant raises temperature approximately 50° or more

IV. Environment

- #### A. Are we willing to destroy environment to let progress in the field of energy continue?

V. Summary

- #### A. Reminder of assignment

VI. Fuel-burning exercise

References: * B2, B7, B10-11, M1-2, P4, P6

* See p. 136.

Lesson No. 4

Subject: Alternate Sources of Energy

Assignment: Report on at least five alternate energy sources

Objective: To enable the student, with the aid of lecture and references, to write a short (one-half to one page) report on at least five alternate sources of energy (including history, present use, operation, and future use) which will be evaluated by the instructor.

Time: Two hours

Teacher Activity: Lecture, discussion

Student Activity: Notes, discussion

Audiovisual: Overheads, slides

- I. Review of previous lesson
 - A. Questions
 - B. Reminder of assignment on pollution due tomorrow
 - C. Analyze fuel-burning exercise
- II. Alternate energies
 - A. Developed from fuel shortage
 - B. Developing technology
 - C. Future importance
 - 1. Careers
- III. Basic alternate sources
 - A. Solar
 - B. Wind
 - C. Geothermal
 - D. Gravitational
 - E. Methanol
 - F. Hydrogen and Alcohol (fuel cells)
- IV. Solar
 - A. The sun the source of all energy
 - B. Two days, production equals energy of all remaining oil, gas, and coal
 - C. Historic use
 - 1. 1878 World's Fair in Paris
 - 2. Farmers drying crops
 - D. Categories
 - 1. Photovoltaic cells
 - a. Works on chemical reaction to produce electricity
 - b. Utilized in space
 - c. Expensive
 - d. Inefficient (10-25%)
 - 2. Collector panels
 - a. Liquid
 - (1) Sun's rays heat liquid inside panels
 - (2) "Greenhouse effect"
 - b. Air (overhead)
 - (1) Sun heats air flowing through panel
 - (2) No problems with freeze-up in the winter
 - c. Basic cost
 - (1) \$4 to \$7 per square foot
 - (2) Whole panels—\$144 to \$600
 - (3) Controls—\$700 to \$900 (including storage)
 - (4) Total system costs two and one-half to three times as much as conventional heating system
 - (5) Cost beginning to decrease as panels go into mass production and oil and gas prices continue to rise
 - (6) Danger of fraud

E. Materials

1. Aluminum
 - a. Corrodes easily unless coated
2. Steel
 - a. Corrodes easily and is heavy
3. Copper
 - a. Costly but conducts heat well

V. Wind

- A. Development of ancient technology
 1. Used for pumping water and grinding grain
- B. Varies from place to place; speeds irregular
- C. Small-scale generation tested throughout country
 1. Feasible in remote areas
 2. Feasible in areas with average winds of seven miles per hour or more
 3. Units still costly and require substantial capital layouts
 4. More experimentation needed
- D. Large-scale generation being studied and done
 1. Problems
 - a. Cost
 - b. Blade angles or pitch
 - c. Height of construction necessary to fully utilize winds
 - d. Nonconstant production of electricity
 - (1) Storage a big problem
 - (2) Uses low discharge batteries

VI. Geothermal

- A. Tapping earths' energy
 1. Reservoirs inside earth of hot brine or steam
 2. Utilized to run turbines
- B. Natural steam field in California
 1. Could satisfy more than 40% of electrical needs of city the size of San Francisco
- C. Problems
 1. Inefficient conversion
 2. Few natural steam fields in the United States
 3. Cost
 4. Turbines tend to deteriorate more quickly because of brine solution composition

VII. Gravitational

- A. Utilizes rotation of earth to produce energy
- B. Basically uses tides
 1. Incoming tides stored in container (e.g., dam)
 2. Water flows out through turbines that run generators as energy is needed
- C. Mechanical device at sea converts bobbing of waves into usable energy

D. Problems

1. Costly and still very experimental
2. Geographical locations

VIII. Methanol

A. Gas made from municipal wastes through process of anaerobic digestion

1. As wastes decay bacterial actions produce gas that can be burned

B. Advantages

1. Easily stored
2. Does not cause dieseling or back firing in automobiles
3. Non-polluting
4. Wastes obtained almost anywhere
5. By-product usable as manure

C. Disadvantages

1. Extremely high octane
 - a. Octane rating of 120 or more
 - b. Highly flammable when mixed in proper proportions of air
2. Can supply only limited amount of energy

IX. Hydrogen and Alcohol

A. Hydrogen

1. Produced from water
 - a. Clean burning
2. Expensive to produce
3. Storage and transportation problems
4. Can be converted into methanol

B. Alcohol

1. Clean burning
2. Expensive to produce
3. Nonpolluting

X. Other sources

A. Temperature gradient of sea

B. Fuel cells

C. Magnetohydrodynamic

1. Pulverizing coal under tremendous temperature and passing it through magnetic field to cause an electromotive force to result

XI. Summary

A. Reminder of assignment

References:* B1-11, M1-4, P1-11, S1-4

* See p. 136.

REFERENCES

Books

1. Producing Your Own Power
2. Energy: Use, Conservation, and Supply
3. Energy Primer
4. Power—Prime Mover of Technology
5. Solar Energy Home Design in Four Climates
6. Design with Wind
7. Energy for Survival
8. Direct Use of the Sun's Energy
9. Handbook of Homemade Power
10. Energy Conservation: Experiments you can do
11. Energy-related materials, 3 vol.

Magazines and Journals

1. Alternative Sources of Energy
2. Energy and Power Journal
3. Popular Mechanics
4. Popular Science

Pamphlets

1. An Introduction to the Use of Wind
2. Solar Energy Hardware
3. Wind Energy Hardware
4. Energy Reporter
5. Breeder Reactor
6. The Energy Crisis
7. Fusion
8. Geothermal Energy
9. Oil Shale
10. Solar Energy
11. Technology for Society—11 pamphlets on energy sources

Films

1. See ERDA Energy film catalog

Slides and Filmstrips

1. Basic Solar Slide Kit
2. Wind Slide Kit
3. Solar Collectors Slide Kit
4. Solar Buildings Slide Kit

Energy Resource List
from *Energy Curriculum*
by FREDRICK E. POSTHUMA

Here is an annotated bibliographical list of energy resources available free or at a nominal cost. They make excellent resources for students and instructors.

Books

Title: *Energy Primer: Solar, Water, Wind and Biofuels*, ed. Richard Merrill et al.
From: Portola Institute
540 Santa Cruz Avenue
Menlo Park, CA 94025

Cost: \$4.50

Covers experiments, manufacturers, and equipment. An excellent resource for designing and building energy systems. It also has a multitude of addresses.

Title: *Handbook of Homemade Power*, Mother Earth News Staff
From: Bantam Books
414 E. Golf Rd.
Des Plaines, IL 60016

Cost: \$2.25

Covers several areas of energy and sources for additional information.

Title: *Producing Your Own Power: How to Make Nature's Energy Sources Work for You*, ed. Carol H. Stoner
From: Vintage Books (Random House)
457 Hahn Rd.
Westminster, MD 21157

Cost: \$3.95

Covers several areas of energy such as wind, solar, and wood. It also shows small scale designs for practical uses.

Title: *Last Whole Earth Catalog* (\$6.00)
The Whole Earth Epilog by Stewart Brand (\$4.00)
The Co-Evolution Quarterly
From: Whole Earth Truck Store
588 Santa Cruz Avenue
Menlo Park, CA 94025

The first two books are catalogs containing energy materials such as wood stoves, solar heaters, etc. The third listing is a continuing magazine supplement to the Whole Earth Catalog/Epilog. An interesting publication to have.

Title: *Energy, Earth and Everyone* by Medard Gabel
From: Straight Arrow Books
625 Third St.
San Francisco, CA 94107
Cost: \$4.95

This is an excellent resource containing three sections: energy for the earth—a look at what we have and future outlooks; energy sources—a discussion of sources and uses; global energy development—developmental strategies of solar, wind, and other forms of energy.

Title: *Future Energies* by Roy Meador
From: Ann Arbor Science Publications
P.O. Box 1425
Ann Arbor, MI 48106
Cost: \$1.95

Provides a summary of future energy prospects for humankind with emphasis on the most promising sources.

Title: *Energy and Man: Technical and Social Aspects of Energy*, ed. M. Granger Morgan
From: IEEE Press
445 Hoes Lane
Piscataway, NJ 08854
Cost: Not available

Written for new students and professionals dealing with the technical and social aspects of energy. Contains chapters written by experts in their respective fields on such things as windmills, fuel cells, flywheel storage, etc. Good reference book.

Title: *Fueling the Future: Energy Sources and Environmental Effects* by Richard T. Sheahan
From: St. Martin's Press, Inc.
175 Fifth Ave.
New York, NY 10010
Cost: \$7.95

Describes conventional and nuclear power plants, and explains the major environmental concerns and ways to control air, water, and land pollution. The book also assesses the present and future in terms of energy.

Title: *Three Hundred Fifty Ways to Save Energy (and Money) in Your Home and Car* by Henry R. Spies et al.
From: Crown Publishers, Inc.
419 Park Ave. South
New York, NY 10016
Cost: \$3.95

Ways to conserve energy and save money in your home and with your car.

Title: *First Book of Solar Energy* by John Hoke

From: Franklin Watts, Inc.
730 Fifth Ave.
New York, NY 10019

Cost: \$3.90

Explains solar energy and its applications. Also contains activities and projects which may be done using solar energy.

Title: *Fuel Cells: Power for Tomorrow* by D. S. Halacy, Jr.

From: World Publishing Company
2080 West 117th St.
Cleveland, OH 44111

Cost: Not available

Gives the history, operation, application, construction, and future of fuel cells.

Title: *Survival Two Thousand One: Scenarios from the Future* by Henry E. Voegeli and John J. Tarrant

From: Van Nostrand Reinhold Co.
Lepi Order Processing
7625 Empire Dr.
Florence, KY 41042

Cost: \$5.95

An effort to help the student understand what was happening in the past, what is being done now, and what we can look forward to in the future.

Title: *Design with the Wind* by Douglas R. Coonley

From: Total Environmental Action (Cheshire Books)
Church Hill
Harrisville, NH 03450

Cost: \$7.00

Investigates the creative uses of wind that are possible with proper building design.

Title: *Solar Energy and Shelter Design* by Bruce Anderson and Michael Riordan
From: Total Environmental Action

Cost: \$7.50

Looks at basic issues underlying the need for the use of solar energy, discusses energy conservation, analyzes ways of collecting and using solar energy, and concludes with a description of most solar projects.

Title: *Direct Use of the Sun's Energy* by Farrington Daniels

From: Total Environmental Action

Cost: \$1.95

A well-documented discussion of the multiple uses of the sun's energy. Topics covered range from water heating and crop drying to heat engines and photo-voltaic conversion.

Title: *Energy for Survival: The Alternative to Extinction* by Wilson Clark

From: Total Environmental Action

Cost: \$4.95

Widely acclaimed for its encyclopedic coverage of both the potential of the many alternative energy sources as well as the limits of traditional sources.

Title: *The Energy-Environment Source Book*

From: National Science Teachers Association
1742 Connecticut Ave., N.W.
Washington, D.C. 20009

Cost: \$4.00

Examines issues, problems, and facts of energy-environment-economic interactions.

Title: *Energy-Environment Materials Guide*

From: National Science Teachers Association

Cost: \$2.00

A bibliography of authoritative and accessible energy literature.

Title: *Energy and Order*

From: Friends of the Earth, Inc.

125 Spear

San Francisco, CA 94105

Cost: \$3.00

A new approach to teaching energy, complete with lesson plans.

Journals and Magazines

Title: *Alternative Sources of Energy*

From: ASE

Route 2, Box 90A

Milaca, MN 56353

Cost: 6 issues for \$10.00 or 12 issues for \$18.00

Covers many energy areas. Written for practical applications; contains additional references and sources of information. This magazine is strongly recommended.

Title: *Earthbeats*

From: Communications Office

University of Wisconsin

Sea Grant College Program

1800 University Ave.

Madison, WI 53706

Cost: Free

A newspaper based on stories from *Earthwatch*, a daily environmental radio program heard over most Wisconsin stations. Really another down-to-earth newspaper containing many interesting and current facts on energy.

Title: *Popular Mechanics*

From: Popular Mechanics

Subscription Dept.

224 W. 57th St.

New York, NY 10019

Cost: \$7.00 for one year

An excellent magazine with usually several articles and projects on energy. A good resource.

Title: *Popular Science Monthly*

From: Popular Science

380 Madison Ave.

New York, NY 10017

Cost: \$6.95 for one year

A magazine found in almost all schools. For the past couple of years it has carried articles on energy and power.

Title: *Energy and Power Journal*

From: NECEP

P.O. Box 618

Concord, MA 01742

Cost: Subscription rate \$8.00 for one year

Membership \$10.00 for one year

The NECEP is a nonprofit organization chartered in Washington, D.C. for the purpose of developing a high level of civic literacy as to the energy and power scene. Strongly recommended.

Title: *Earth Journal*

From: Minnesota Geographic Society
P.O. Box 6181
Minnehaha Sta.
Minneapolis, Minn. 55406

Cost: \$3.00 for one year

A new journal containing interesting down-to-earth articles on energy and related subjects, published quarterly.

Pamphlets

Title: *What's Behind the Energy Crisis?*

From: Ambassador College Press
P.O. Box 11
Pasadena, CA 91123

Cost: Free

An excellent pamphlet for handout to students or for use in your reference library. Covers the energy crisis, the world's crippling dependence on oil, and solutions to energy problems.

Title: Numerous pamphlets on energy

From: Technical Information Center
Energy Research and Development Administration
P.O. Box 62
Oak Ridge, TN 37830

Cost: Free in limited quantities

Free pamphlets on such things as the energy crisis, solar energy, and other related information. Write and ask for a listing of all available information.

Title: *An Introduction to the Use of Wind* by Douglas R. Coonley

From: Total Environmental Action
Church Hill
Harrisville, NH 03450

Cost: \$2.00

Background and introduction; considerations in use, methods; potential energy available; types and size of equipment; costs; history; evaluated listings of twenty-eight manufacturers and seven plans; energy storage.

Title: *Technology for Society—Sources of Energy*

From: Technology for Society
U. W. Stout
Menomonee, WI 54751

Cost: Approx. \$12.00

Numerous pamphlets (approximately ten) on areas such as coal, solar, geothermal, oil, wind, hydro, etc. Contain the history of each source, applications, and activities for the classroom. A highly recommended resource that should be purchased.

Movies, Slides, and Filmstrips

Title: *Energy—Use it wisely around the home*

From: Photographic Division
Office of Communication
U.S. Dept. of Agriculture
Washington, DC 20250

Cost: \$18.50

A slide/tape series on energy conservation measures around the home.

Title: *Energy Sources*
From: BFA Educational Media
2211 Michigan Avenue
Santa Monica, CA 90404

Cost: Not available

Contains two parts each with eight filmstrips and cassettes on energy sources.

Title: *Energy Films Catalog*
From: Energy Research and Development Administration
Film Library
P.O. Box 62
Oak Ridge, TN 37830

Cost: Free

A catalog of free loan films that can be obtained from ERDA. Many are outdated but some extremely good films are current and very useful in the classroom.

Others

Title: *Living with Energy*
From: Standard Oil Company
Mail Code 3705
200 E. Randolph Dr.
Chicago, IL 60601

Cost: Free

A file of four spirit masters demonstrating that Americans can no longer live with energy as they did in the past. Excellent handout for students to emphasize their life-style.

Title: *Energy Reporter*
From: Federal Energy Administration
Energy Reporter Subscriptions
Room 2115
Washington, D.C. 20461

Cost: Free to officials of school systems with orders on school letterhead.
Informative monthly report on energy activities in and out of government.

Title: *The Household Energy Game*
From: University of Wisconsin Sea Grant Program
1800 University Avenue
Madison, WI 53706

Cost: Free

Designed to show the dependence of the family on fossil fuels. By calculating how much energy the family uses, you can get an idea of how your household energy consumption compares to today's average American household and where you might be able to conserve energy.

Title: *Anything and Everything*
From: Technical Information Center
Energy Research and Development Administration
P.O. Box 62
Oak Ridge, TN 37830

Cost: Most information free.

A national clearinghouse for energy information. Write and ask for whatever they have.

Prices may be subject to change.

Fredrick E. Fusthuma, editor of this collection of classroom teacher-oriented materials, believes "... it is time to make a new and seriously relevant effort to our classrooms. It is time to begin about educational changes and concerted development in relation to the energy and growth field." The focus of *Energy Education K-12* is of interest to many educators. Today, there are some promising developments; new and better materials are becoming available, and districts have finally realized that the problem is real. Consequently, it is extremely important that today's young people understand energy and its implications—one might say their lives depend on it.

Energy and Education: Teaching Alternatives is designed for those who are just beginning as well as for those who are experienced. It contains several sections on a broad range of topics, sections including problems and their causes, goals, needs, needs, the relationship between science and energy, and energy conservation. Two complete film units are provided, as well as a resource list of related materials. This publication is the *Journal of Learning* series can serve as the basic handbook and resource tool for teachers and students, regardless of science level.

The editor, Fredrick E. Fusthuma, provides preface and chapter comments for each chapter, as well as four lesson plans to help teachers present effective classroom activities in energy education. Mr. Fusthuma teaches Industrial Education at Westfield High School, Westfield, Wisconsin.

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